Multi-criteria evaluation of small ruminant farming systems sustainability in Lebanon and Algeria

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Abstract. The sustainability of 129 small ruminant farming systems in Lebanon and 100 in Algeria was analysed on the basis of the quantitative multi-criteria method IDEA (Indicateurs de Durabilité des Exploitations Agricoles, or Farm Sustainability Indicators). Forty-one indicators covering the agro-ecological (including biodiversity, land management, agricultural practices), socio-territorial (product quality, employment and services, ethics and human development) and economical (viability, independency, transmissibility and efficiency) dimensions of sustainability were considered and applied in different contexts: sedentary, semi-transhumant, transhumant, semi-nomad or nomad production systems. Some indicators of the original method were inadequate in these systems, other were reformulated on the basis of appropriate references. In a semi-arid and pastoral context, the stocking rate, soil fertilisation, or nitrogen balance are examples for which more specific information is needed. The relative weighting of indicators deserves also attention. This methodological approach allowed identifying different categories of systems according to the three dimensions of sustainability. Global scores of sustainability were attributed to the more diversified systems such as the sedentary or horizontal transhumant ones. This method can be used to generate decision support tools and to model the sustainability of livestock farming system.

Keywords. Sheep – Goat – Livestock farming system – Sustainability – IDEA – Algeria – Lebanon.

Evaluation multicritères de la durabilité des systèmes de production de petits ruminants au Liban et en Algérie

Résumé. *Le niveau de durabilité de 129 systèmes de production de petits ruminants au Liban et de 100 en Algérie a été analysé sur la base de la méthode multicritères IDEA (Indicateurs de Durabilité des Exploitations Agricoles). Quarante et un indicateurs couvrant les dimensions agro-écologique (biodiversité, organisation de l'espace, pratiques agricoles), socio-territoriale (qualité des produits, emploi et services, éthique et développement humain) et économique (viabilité, indépendance, transmissibilité, efficience) de la durabilité ont été mis en œuvre dans différents types de systèmes de production : sédentaire, semi-transhumant, transhumant, semi-nomade ou nomade. Certains indicateurs de la méthode originale se sont avérés inopérants, d'autres ont été reformulés sur la base de références plus adaptées. Dans un contexte pastoral en milieu semi-aride, le chargement animal, la fertilisation des sols, ou le bilan azoté requièrent une approche spécifique. De plus, la pondération relative des indicateurs doit être réévaluée. L'approche méthodologique mise en œuvre a permis de caractériser les systèmes selon les différentes dimensions de la durabilité ; les systèmes les plus diversifiés (sédentaires ou transhumants horizontaux) présentent les meilleurs scores globaux. Cette méthode peut servir de base au développement d'outils d'aide à la décision et à la modélisation de la durabilité des systèmes de production.*

Mots-clés. *Ovins – Caprins – Systèmes de production – Durabilité – IDEA – Algérie – Liban.*

I – Introduction

The need to take into account the sustainability of livestock farming systems in order to maintain them in a viability domain, while responding to the needs of current and future society demand without compromising the natural resources is now generally acknowledged (Vavra, 1996; Gibon *et al.,* 1999; Thompson and Nardone, 1999). Assessment of farming systems sustainability is a mean to control the degree of achievement of this objective.

Assessing system sustainability (von Wirén-Lehr, 2001) aims at different operational goals: (i) establish a diagnosis of the system; (ii) compare its status with a reference or a group of similar systems; (iii) deliver, above a given threshold, a quality sign such as a label; (iv) evaluate system dynamics by comparing its performance at successive times; and (v) evaluate system response to management, or to public policies, as well as to change in the environmental conditions.

Besides modelling tools (van Calker *et al.,* 2004; Tichit et *al.,* 2004) reproducing the functioning of a system, which are, up to now, limited to a part of the whole system, and subjective approaches used for discussions with or between farmers (e.g. the “Arbre” method, Pervanchon, 2006), methods based on indicators are increasingly widespread (Andreoli and Tellarini, 2000; Girardin *et al.,* 2000; Van der Werf and Petit, 2002; Häni *et al.,* 2003; Nahed-Toral *et al.,* 2006). An indicator quantifies and simplifies phenomena and helps understanding realities which could not be otherwise fully seized in their complexity (Bosshard, 2000; Hueting and Reijnders, 2004).

Among the indicator-based available assessment methods, a few integrate the three dimensions of sustainability defined by the International Institute of Environment and Development (Mebratu, 1998), namely the environmental, social and economical pillars. The method IDEA (Farm Sustainability Indicators: Vilain *et al.*, 2003; Zahm *et al.*, 2006), developed in France since 1998, takes into account these three components in a balanced way.

Objective of this paper was to adapt IDEA method to small ruminant farming systems in Mediterranean countries (Lebanon, Algeria). The main principles of the method are presented by focusing on the adaptations performed in order to fit to the case studies. Elements of validation are discussed together with its interest for the understanding and management of small ruminant farming systems.

II – Method presentation

The approach relies on the fulfilment of 16 diverse and complementary objectives directly related to sustainability: adaptability (aptitude to respond to changes of external or managerial conditions), respect of biodiversity, preservation of non-renewable resources, soil preservation, water management, atmosphere preservation, landscape preservation, product quality, quality of life, ethics, local development, citizenship, human development, employment, animal welfare, and consistency (coordinated actions to achieve sustainability of the system in the technical, social and economical dimensions). The completion of these objectives is monitored through a set of 41 indicators, each one being related to 2 to 7 objectives.

The agro-environmental sustainability scale is divided into three components: biodiversity (represented by 5 indicators: diversity of annual/temporary crops, of perennial crops, of associated vegetation, of animal breeds and species, and preservation of genetic heritage), organisation of space (7 indicators: cropping patterns, field size, organic matter management, ecological buffer zones, protection of natural heritage, stocking rate, fodder area management) and farming practices (7 indicators: fertilisation, effluent processing, pesticides and veterinary products, animal welfare, soil protection, water protection, energy dependence).

The socio-territorial scale is represented by three components: product and land quality (5 indicators: quality of feedstuffs produced, buildings and landscape heritage, processing of non-organic waste, accessibility of space, social involvement), employment and services (5 indicators: short trade circuits, services and multi-activities, contribution to employment, collective work, probable farm sustainability) and ethics and human development (6 indicators: contribution to the world food balance, training, labour intensity, quality of life, isolation, hygiene and safety).

The economical scale is represented by four components: economic viability (2 indicators: income by worker, economic specialisation rate), independency (2 indicators: financial autonomy, reliance on subsidies), transferability (operating capital level), and efficiency (operating expenses as a proportion of income). The small number of indicators in the economical domain is due to the fact that they are already synthetic ones.

Each indicator is given a specific weight (maximal scores from 3 to 13 for the first two scales, from 10 to 25 for the economical scale) according to the importance of its contribution to the sustainability of the system on the basis of an expert-based consultation. The potential number of points for the indicators inside a given component is higher than the maximal score of the component, which means that different strategies or conditions make possible to achieve an optimal degree of sustainability. The indicators are constructed either from qualitative observations, quantitative data related to external references, or by farmer subjective appreciation. They have been elaborated through an expert-based process, and tested in different situations, with regular adjustments (last edition: 2008; web site: http://www.idea.portea.fr).

The IDEA method has been used in different contexts in France (such as crop systems, viticulture, mixed crop-livestock farming, cattle fattening production), but rarely on small ruminant farming systems (Bossis, 2004).

III – Method adaptation to the Mediterranean context

Mediterranean small ruminant farming systems are generally managed under extensive production modes, with different levels of pastoral component (pure pastoral, sylvo-pastoral, agro-pastoral) in association with stationary, transhumant or nomadic modes. They are submitted to harsh (arid or semi-arid) climatic conditions, roughage scarcity, dependence on importations for feedstuffs (Rancourt *et al.,* 2006); furthermore, they also differ in terms of references relative to agro-environmental, but also social and economical aspects.

In a survey conducted on 129 Lebanese small ruminant systems (Srour, 2006; Srour *et al.*, 2007), sustainability was assessed and discussed as a function of the type of farming system (zero grazing, sedentary, horizontal or vertical transhumance, or semi-nomadism). Each interview was 3 to 5 hours long, and explored the system through 170 questions. Another survey conducted on 100 farming systems in the Wilaya of Djelfa (Algeria), a semi-arid area located in the central high plateau, mainly devoted to sheep breeding, explored, with the same methodology, agro-pastoral, agro-sylvo-pastoral, semi-transhumant, transhumant and nomadic systems.

The objectives identified in the original method, as well as the denomination and significance of the indicators were retained, but, in order to make the process context specific, modifications were introduced on indicators' modalities, notation tables, or indicator weighing. Computational modalities were modified for 21 indicators. This consisted in only slight adjustments for 13 of them, but in bigger alterations for 8 of them, such as quality of foodstuffs, contribution to employment, or transferability.

Notation scales were altered for nearly all indicators (36 of them) in order to fit the observed values to the local references which were prevalent in the country. Also, the weight assigned to each indicator was modified for 30 of them in order to adapt the balance among indicators inside a given component. So, the relative weight of associated vegetation (mainly ornamental trees), effluent processing, quality of foodstuffs produced (due to the lack of official quality signs), processing of non-organic waste, contribution to employment, collective work or economic viability was reduced, whereas field size, animal welfare (after an upgrading of the design of the indicator), water management, space accessibility, social involvement, probable sustainability of the system, quality of life, economic specialisation, or efficiency were relatively emphasized. The adjustments operated to the original method are presented in detail in Srour (2006), and synthesised in Sour *et al.* (2007).

Difficulties were experienced for the calculation of some indicators. For instance in a pastoral context, stocking rate would imply to know the nutritional value of rangeland; nitrogen balance would require information not always available; transferability did not rely upon the same ground than in Europe, where the value of the operating capital to be compensated by the buyer/successor is the main hindrance. The lack of written documents and accountancy was also an obstacle to the evaluation of economic or technical parameters.

IV – Method evaluation

To be considered as valuable, an indicator used in an assessment system must fulfil a set of criteria (Mitchell *et al.,* 1995; Bockstaller *et al.,* 2008). It should be:

(i) Relevant: the indicator should represent and measure what it is designed to measure.

(ii) Measurable: the data used to calculate it must be available in an easy and financially feasible manner.

(iii) Actionable: derived from parameters which can respond in a positive way to adapted actions.

(iv) Reliable: it must be measured in a consistent manner which can be repeated over the time or by different persons with the same results if the conditions are constant.

(v) Sensitive: it must react as a function of the variation of parameters.

(vi) Robust: it must keep its validity in different situations (e.g. different systems or environments).

(vii) Non redundant: indicators should be independent, not measuring the same parameter than other ones.

Furthermore, the assessment system as a whole should be: (i) Representative: reflecting values associated to sustainability (which is represented by the above-mentioned underlying objectives); (ii) Exhaustive: taking into account all the dimensions of sustainability; and (iii) Useful: being pertinent for end-users.

The data collected allow us to demonstrate sensitivity, robustness and independency of the system.

The effectiveness of sensitivity was checked by examining the distribution of the values taken by a given indicator. A broad distribution with both low and high values is more likely to indicate that the indicator accounts for favourable and unfavourable situations, and, therefore, responds to variations of the measured parameters. This was the case for indicator A9 (presence of ecological buffer zones) (Fig. 1). Conversely, indicator B7 (services, multi-activities) displayed 97.7% of null values on a scale of 5, and A5 (conservation of genetic heritage) mainly maximal values (on a scale of 3). In these cases, the observed distributions were justified by the fact that most of the non commercial service to the territory or side-activities (such as agro-tourism or pedagogic farm) were absent, and that most of the small ruminant breeds were native ones (only few systems were based on imported breeds). These observations, even distributions or, if unbalanced, justified by arguments, were in accordance with the effective sensitivity of the indicators. Furthermore, the positions of extreme values were compared with external references in order to verify that all situations likely to occur were taken into account by the indicator.

Sensitivity was also explored by examining the scores obtained by individual farms for the three scales of sustainability. Fig. 2 shows that scores ranged from 17.5 to 66 for the agro-environmental scale, from 29 to 74 for the socio-territorial one, from 15 to 90 for the economical one, and from 15 to 58 for the global sustainability (estimated by the lowest value of the three scales for each system), on a total of 100 (Lebanese data, 129 farming systems). The corresponding coefficients of variation, a measure of sensitivity (Thomassen and de Boer, 2005), were respectively 28.0%, 15.7%, 27.0% and 25.1%. From these observations, it can be concluded that the method was able to detect differences in the sustainability score of the farming systems surveyed.

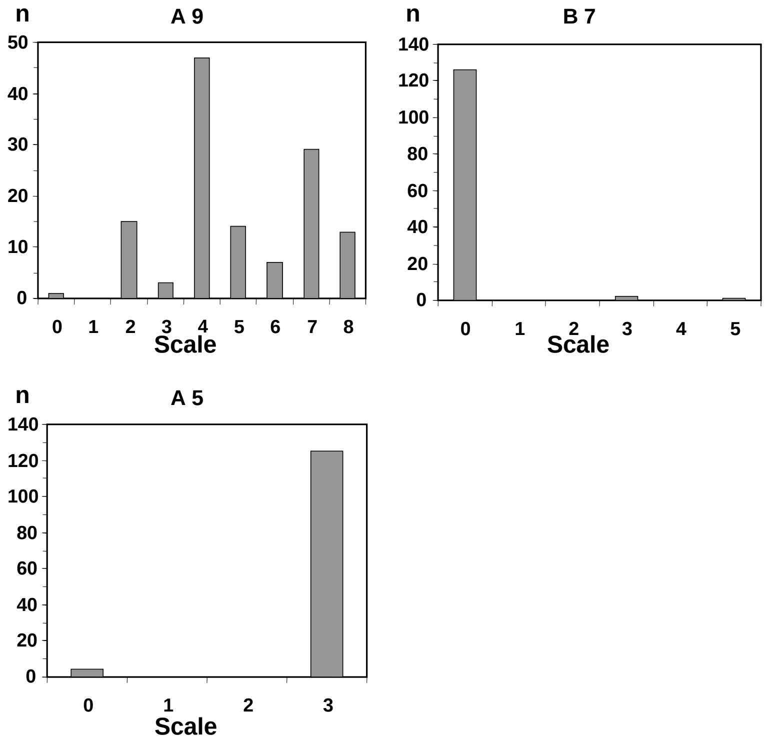

Fig. 1. Distribution of the scores for indicators A9 (presence of ecological buffer zones), B7 (services, multi-activities) and A5 (conservation of genetic heritage).

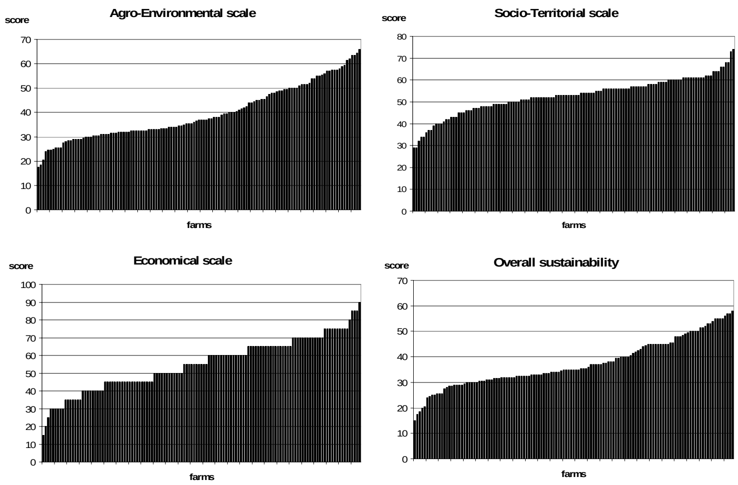

Fig. 2. Scores of agro-environmental, socio-territorial, economical scales and overall sustainability for 129 Lebanese small ruminant farming systems.

The robustness of the method was analysed by comparing the scores obtained by contrasted farming systems. As shown in Fig. 3, the distribution of the sums of the scores of the three scales was comparable between the different types of Lebanese small ruminant farming systems (ranging between 103 and 192 points). So, even if some differences were observed among systems (zero grazing: 148.5 ±14.5[ab]; sedentary: 159,6 ±2.8[b]; semi-nomad: 142.0 ± 7.0[a]; horizontal transhumance: 159.2 ± 5.2[b]; vertical transhumance: 137.6 ± 2.3[a]), the method remained valid in all cases.

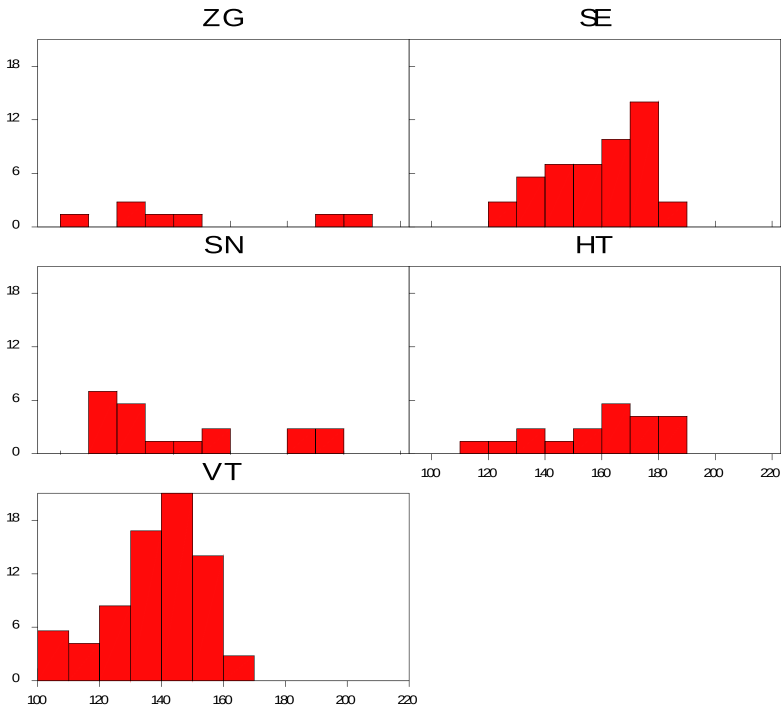

Fig. 3. Distributions of the sums of the scores of agro-environmental, socio-territorial and economical scales for zero grazing (ZG, n=7), sedentary (SE, n= 35), semi-nomad (SN, n= 17), horizontal transhumance (HT, n= 17) and vertical transhumance (VT, n= 53) systems in Lebanon (n=129). (The scales of the abscissa axes are the same for all histograms).

Regarding the independency of the sets of indicators (Fig. 4), correlations between agro-environmental and socio-territorial scales ($r= 0.307$, $r^2= 0.094$, $P< 0.01$), agro-environmental and economical scales ($r= 0.212$, $r^2= 0.045$, $P< 0.05$) and socio-territorial and economical scales ($r= -0.08$, $r^2= 0.006$, $P> 0.10$) showed that, if the three scales were not totally independent, the r^2 values indicated that contribution to the overall variability was low (respectively 9.4%, 4.5%, and 0.6%), and that, for example, a high value of agro-environmental score could be associated either with a low or a high value of the economical performance. Moreover, individual indicators were constructed using different elementary variables.

Further validation (Bockstaller and Girardin, 2003) could be performed by: (i) applying the method on another set of farms representing a larger range of diversity; (ii) refining the references either from existing data bases, bibliographic searches or from scientifically designed observations; or (iii) by the consultation of experts from different positions (researchers, technical advisers, or farmers) in a multidisciplinary approach (considering animal, plant, and soil sciences, water management, pastoralism, ecology, geography, sociology and economy).

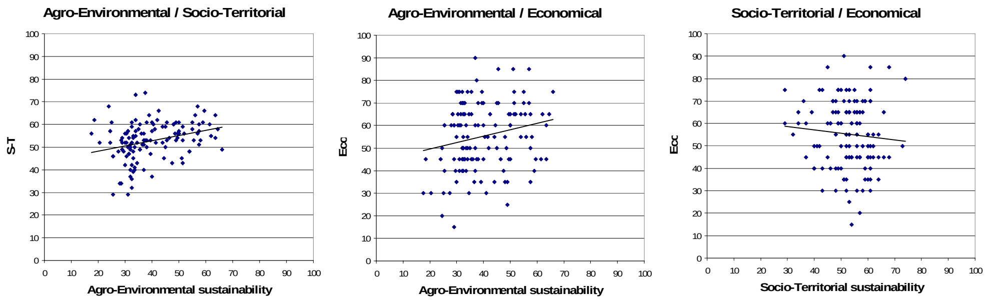

Fig. 4. Correlations between agro-environmental, socio-territorial and economical scores (n = 129).

V – Conclusions

This study highlights that the principle of the IDEA multi-criteria method of sustainability assessment is generic by nature and can be used in a large variety of farming systems. The fundamental objectives, the denomination and significance of the indicators have been successfully applied for evaluation of small ruminant systems. However its implementation in a Mediterranean context requires adaptations in calculation mode, in the notation tables and in the weighting of indicators.

Major difficulties arise from data availability or uncertainty for some parameter quantification (e.g. soil fertilisation, pesticide use, nutritive value of rangeland, or economic data). Also, references specific to the case study may be missing and should be completed. If the evaluation system used here proved to be globally operational and efficient, under different conditions (relative to the countries or production systems), further validation is needed.

Developments to be considered are: (i) the monitoring of the system sustainability score throughout time and in response to corrective actions; (ii) the analysis of production systems in relation to their sustainability score; (iii) the development, on the bases of the structure of indicators, components and scales of the present method, of decision support systems (Girardin *et al*., 2005) for technical advisers or policy makers; and (iv) the development of models for the simulation of system responses in terms of sustainability.

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