PROPOSAL OF ENVIRONMENTAL INDICATORS OF SUSTAINABILITY FOR SMALL RUMINANT PASTORAL HUSBANDRY

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SUMMARY This paper is the continuation of a previous study presented by authors in the FAO-CIHEAM seminar in Seville in 2005, in which, a preliminary analysis was made of the use of FAO-CIHEAM indicators to evaluate sustainability of small ruminant farms. The paper presented now provides a provisional list of environmental indicators adapted to small ruminant farms with respect to eight aspects: agricultural practices, soil, water, landscape, energy, residues, animal wellbeing, and biodiversity. Further work is necessary to complete and perfect this list.

Keywords: indicators, sustainability, goat production systems.

RESUME Cet article constitue la suite d’un étude présenté pour les auteurs au Séminaire FAO-CIHEAM célébré à Séville en 2005, dans lequel un analyse préliminaire a été fait sur l’utilisation des indicateurs FAO-CIHEAM pour l’évaluation de la durabilité des exploitations des petits ruminants. L’article actuel présente une liste provisoire d’indicateurs qui font référence aux aspects environnementales des exploitations de petits ruminants, classés en huit aspects: pratiques agricole, sol, eau, paysage, énergie, bien être animal et biodiversité.

Mots clés: indicateurs, durabilité, systèmes de production caprine.

INTRODUCTION

Currently, in many symposiums, viability of the conventional model of productivity of livestock development is being questioned, as it ignores negative repercussions of this system, such as environmental deterioration, resource overuse, abandonment of the countryside, and domination of the market by multinationals. Considering these drawbacks, the concept of sustainability is appropriate for evaluating livestock production systems, and may be synthetically defined as the ability of a system to manage productivity or utilize a resource without reducing its physical stock through time, even when submitted to stress or strong perturbations (Conway, 1985).

The process of evaluating sustainability becomes a useful planning tool, as it points out prevalent tendencies for change (probable scenario) in productive systems, and contributes to defining desirable scenarios, with planned intervention to the systems which would modify current undesirable tendencies (Nahed et al., 2006b). On the other hand, evaluation of any animal production system implies identification of variables and integration of indicators for recording data of distinct events and results of productive activities. Presently, in the small ruminant sector, this is done in an almost anecdotal manner. The authors of this study, conscious of the difficulties in recording and later using information on the level of farm, are working on selection of the most adequate indicators for evaluating sustainability of goat systems in general, and specifically those linked to pasturing. In this sense, in the FAO-CIHEAM seminar in Seville in 2005, a preliminary analysis was made of the use of FAO-CIHEAM indicators to evaluate sustainability of small ruminant farms (Nahed et al., 2006b). This proposal, which focused on technical-economic indicators - those covered by the FAO-CIHEAM method - was limited in terms of environmental and social indicators. Based on the aforementioned, and in order to contribute to overcoming the incipient development of integral methodological frameworks which simultaneously evaluate environmental, economic, and social sustainability...
(Masera et al., 1999), the authors propose - as the objective of this study - to elaborate a list of environmental indicators adapted to goat systems, obtained through compared analysis of various methodologies which complete the initial list.

**METHODOLOGY**

Environmental indicators discussed in this study were obtained from the literature on animal production, as well as on methodologies for evaluating sustainability of livestock systems. First, a broad list of indicators was elaborated. This list was discussed among academics knowledgeable of the topic, resulting in a second list of simple (direct) or complex (indirect or integrating) indicators. The operational definition of the indicators or transformation of concepts to indicators or indexes (procedure for precisely measuring or estimating corresponding empirical data) stemmed from the theoretical definition of the indicators, as well as from knowledge and experience on the theme, and was improved by consulting experts on the topics of these environmental indicators. Complex indicators are made up of different variables, individually characterized as positive (yes = 1) or negative (no = 0), according to the presence or absence of the variables, and are estimated using the sum of the values 1 and 0, divided by the number of variables making up the indicator. Complex indicators proposed will be validated in the future by experts of the FAO Observatory in order to formulate a global proposal which also includes those technical-economic indicators already validated by the Observatory.

**RESULTS AND DISCUSSION**

Eight groups of environmental indicators oriented to evaluating sustainability of livestock systems are presented. These indicators were selected according to their importance in analyzing animal well-being, congruence between livestock use and conservation of natural resources, and general contribution of these indicators to sustainable development of livestock systems.

1. **Agricultural practices.** Agricultural practices greatly determine the level of soil conservation and influence soil quality and erosion (Astier-Calderón et al., 2002). This group of indicators is made up of (IFOAM, 1972; Lefroy et al., 2000; Astier-Calderón et al. 2002): i) **Useful Agricultural Surface organically fertilized (%)**, which is a simple indicator; ii) **Manure fertilization (kg/ha cultivated)** - also simple; iii) **Soil Fertility (%)** – a complex indicator made up of several variables concerning various aspects: chemical fertility (pH, cation exchange capacity, and percentage of organic matter), physical fertility (apparent soil density, texture, velocity of water infiltration, structure, and porosity), and biological fertility (level of microbial activity and presence of macro and microfauna - variables characterized as positive if they have the minimum level required for considering a soil fertile, which depends on region and crop type), and iv) **Integral management of agricultural practices**, which is a complex indicator made up of different variables (crop rotation, association of species in forage crops, incorporation of agricultural residues to the soil, refraining from burning residues, refraining from ploughing more than 30% of the total agricultural surface dedicated to goat production, cultivation according to tillage following contour lines, and use of biological controls.

2. **Soil.** Soil quality and conservation depend on various factors (Astier-Calderón et al., 2002). After revision and selection, this group of indicators was essentially made up of those published by IFOAM, 1972. These are: i) **Level of erosion**; ii) **Level of soil compaction**; iii) **Depth of arable soil (cm)**; iv) **Level of salinity (%)**; v) **Rockiness (%)**; vi) **Depth of water (m)** and vii) **Plant cover of the soil (%).** With the exception of the first, all indicators are simple or direct.

3. **Water.** Generally small ruminant systems are located in marginal zones, where water scarcity and quality is a common problem. Therefore, the simple and direct indicators included in this category are (Hayo 2002; Several authors, 2001; Mas de Noguera 2003; Several authors, 2006): i) **Irrigated surface/ total agricultural surface (%)**; ii) **Irrigation method**; iii) **Existence of water availability problems**; iv) **Source of water supply**; v) **Volume of water consumed on the farm (/goat)**; vi) **Presence of amphibians in waterways**; vii) **Presence of aquatic vegetation indicating eutrophication**; viii) **Water turbidity**, ix) **Salt content** and x) **Presence of pesticide residues.**
4. **Landscape.** Landscape is an element essential to identifying a region, and agriculture plays an important role in the regional landscape configuration. Simple indicators selected are (Several authors, 2001; IDEA 2003; Mas de Noguera 2003; Several authors, 2006): i) **Maintenance of woody plant masses** (trees and shrubs); ii) **Preservation of zones of ecological interest**; iii) **Presence of traditional patrimony**; iv) **Presence of herds outside**; v) **Plot dimensions**, and vi) **Scenic beauty** (varied or monotonous).

5. **Energy.** Currently, increasing efficiency of energy use and minimizing energy dependence are objectives of any productive activity. Therefore, indicators referring to energy use, reported by various authors (Ghersa 2002; IDEA 2003; Mas de Noguera 2003; Nahed et al. 2006a) have been included: i) **Contribution of energy indoors per production unit or per animal** (UFL/liter or UFL/goat); ii) **Use of renewable energies**; iii) **Energy dependence** (Equivalent fuel/goat); iv) **Ratio energy extracted/energy supplied** (%).

6. **Residues.** Three aspects determine quantity of residues generated: level of intensification of the farm, availability or lack thereof of owned land to dump manure, and the plan for collection and treatment of farm residues. Indicators most relevant to goat systems (European Union Directives 1991 and 1999; Several authors, 2001; Mas de Noguera 2003; Several authors, 2006) are: i) **Presence of residues in the milk** (antibiotics, hormones, pesticides); ii) **Nitrogen supply in animal excretions** (kg/ha/year) and iii) **Management of residues**, consisting of: capacity for eliminating waters used in cleaning, existence storage area for residues, recycling of manure and appropriate disposal of recipients of toxic residues.

7. **Animal well-being.** Evaluation of animal well-being on the farm is difficult, and may prove costly. The list of indicators selected from different methodologies (FAWC, 1994; DEFRA, 2003; IDEA, 2003;) takes into account the particularities of the goat species and currently existing models of production, as well as ease of data taking. These are: i) **Animal health** (animal liveliness and condition of the coat, hoof problems, visible wounds, adequate disease prevention program); ii) **Feeding quality** (balanced diet, quality and diversity of grasses, adequate distance and time of pasturing, protection and drinking-troughs in pastures, fences in good condition, fresh quality water, and adequate feed-troughs); iii) **Quality of stables** (adequate animal density, appropriate animal groups, appropriate soil conditions, gates, fences, adequate ventilation and cleanliness, and adequate protection from inclement weather); iv) **Appropriate milking conditions** (adequate design of the milking parlor, strict hygiene of the stable, equipment and workers, adequate milking routine, adequate bacteriological quality, and absence of inhibitors in the milk); v) **Quality of human care** (frequent animal visits, good animal treatment, high level of knowledge of animal behavior, and opportune veterinary care). vi) **Well-being of reared** (natural lactation, refraining from tethering the animals, animal density, adequate cleanliness and hygiene, adequate growth rate, incidence of illness, minimal mortality, and appropriate protection from cold, heat, rain, and humidity).

8. **Biodiversity.** The concept of biodiversity is defined as variability among living organisms within the species, among species, and of ecosystems (Moreno, 2001). Various methods exist for measuring diversity of flora and fauna species in natural ecosystems; for example, the Shannon and Simpson indexes. Other more direct procedures are relative abundance and relative frequency of species or breeds. Nevertheless, the most simple and direct measure of diversity is species richness, defined as absolute number of species or breeds of a community or region. Based on the concept “species richness” (Begon et al., 1996) seven simple indicators are proposed as most important in estimating biodiversity in animal production systems: i) **Domestic animal species present** (nº); ii) **Domestic animal breeds present** (nº); iii) **Ratio of autochthonous breeds to those breeds present**; iv) **Cultivated species present > 5% UAS (nº); v) **Non cultivated grass species most consumed by the animals** (nº); vi) **Woody species** (trees and shrubs) **present** (nº) and vii) **Managed agro-ecosystems** (productive activities) **in the unit of production** (nº).

**CONCLUSIONS**

Identification and selection of simple indicators or development of complex indicators requires, on the part of researchers, great care and experience, sharp intuition, and solid knowledge of the topic studied, as well as willingness to receive suggestions from other authors.
Those environmental indicators proposed in this study are related to agricultural practices, soil, water, landscape, energy, residues, animal well-being, and biodiversity. In each situation, only those indicators easily obtained which show high reliability in terms of data taking should be selected. Naturally, this depends on the level of precision desired as well as economic capabilities and human resources available.

These indicators, as well as a group of social indicators currently being developed, will be proposed for validation by experts of the FAO Observatory to develop a global proposal together with those technical-economic indicators already validated by this Observatory. The objective is to motivate researchers and technicians dedicated to animal production to identify, develop, and utilize new indicators in an integrated manner with the objective of evaluating sustainability of animal production systems.

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