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Proposal of environmental indicators of sustainability for ruminant pastoral production systems

Propuesta de indicadores ambientales de sustentabilidad para sistemas de producción de rumiantes en pastoreo

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Resumen

Este artículo es la continuación de un estudio previo presentado por los autores en el Seminario FAO-CIEHAM (Organización para la Agricultura y la Alimentación- Centro Internacional de Altos Estudios Agronómicos Mediterráneos) celebrado en Sevilla, España, en 2005, en el cual se realizó un análisis preliminar acerca del uso de los indicadores de la FAO-CIEHAM para evaluar la sustentabilidad de granjas con pequeños rumiantes. El artículo que se presenta ofrece una lista de 48 indicadores ambientales genéricos, adaptada a las granjas con pequeños rumiantes con relación a ocho aspectos: prácticas agrícolas, suelo, agua, paisaje, energía, residuos, bienestar animal y biodiversidad. Se necesita trabajo adicional para completar y perfeccionar esta lista, la cual se ha obtenido a partir de la consulta a expertos y de una revisión de metodologías existentes.

Abstract

This paper is the continuation of a previous study presented by the authors in the FAO-CIEHAM (Food and Agriculture Organization-International Center for Advanced Mediterranean Agronomic Studies) seminar in Seville in 2005, in which, a preliminary analysis was made of the use of FAO-CIEHAM indicators to evaluate sustainability of small ruminant farms. The paper presented provides a list of 48 generic environmental indicators adapted to small ruminant farms with respect to eight aspects: agricultural practices, soil, water, landscape, energy, residues, animal welfare, and biodiversity. Further work is necessary to complete and perfect this list which has been obtained from a review of methodologies.

Palabras clave

Indicadores, sustentabilidad, rumiantes, sistemas de producción.

Key words

Indicators, sustainability, ruminant, production systems.

Introduction

The concept of sustainability is appropriate for evaluating livestock production systems, and may be 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; Conway, 1994]. It would be necessary to understand that sustainability would include the aspect of changes in resource quality, as these also affect productivity. 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 at the farm level, are working on selection of the most adequate indicators for evaluating sustainability of goat systems in general, and specifically those based on grazing. 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 preliminary list of environmental indicators adapted to ruminant production systems, obtained through compared analysis of various methodologies.

Methodology

Environmental indicators discussed in this study were obtained from the literature on animal production, from a review of methodologies for evaluating sustainability of

livestock systems, as well as the experience from the authors. 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 (ten experts from Mexican and Spanish institutions) 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. Proposed complex indicators are not defined. On one hand, they should be tested at the field level in order to see whether or not they are viable and provide reliable, useful information. On the other hand, these indicators will be validated in the future by FAO experts, in order to formulate a comprehensive proposal which also includes those technical-economic indicators already validated by the Observatory to assess animal production systems sustainability.

Environmental indicators proposed

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. At this first stage in the selection process many possible variables exist for a given indicator and it is difficult to find those which most appropriately describe it. In other cases the variables found are not easily measured and should be changed with others less reliable but more accessible. It may happen too that some selected variables do not exactly measure the indicator but some less relevant collateral aspect [Sarandon, 2002]. All this issues should be assessed in the elaboration of the indicators with field data allowing the choice of the most suitable variables and indicators. This further stage is not covered in this paper.

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-Calderon *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 plowing 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 *et al.*, 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* (l/goat); vi) *Presence of amphibians in waterways*; vii) *Presence of aquatic vegetation indicating eutrophication*; viii) *Water turbidity*; ix) *Salt content*; x) *Presence of pesticide residues*; and xi) *Capture, storage, and distribution of water*.

4. *Landscape*. Landscape is an element essential to identifying a region, and agriculture plays an important role in the regional landscape conformation. 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 outdoors (implying lower infrastructure and input requirements)*; v) *Plot dimensions*, and vi) *Scenic beauty (which motivates its conservation)*.

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 *et al.*, 2002; IDEA, 2003; Mas de Noguera, 2003; Nahed *et al.*, 2006a] have been included: i) *Contribution of energy in the stable per production unit or per animal* (UFL-Milk Fodder Unit, per liter or per 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 appropriately store and organically process manure, and the plan for recollection and treatment of farm residues. Indicators most relevant to goat systems [CR, 1991; CR, 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) as an indicator of nitrogen balance in the system and iii) *Management of residues*, consisting of: capacity for eliminating water used in cleaning, existence of storage area for residues, recycling of manure, and appropriate disposal of toxic residues containers.

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 animals* (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* (n^0); ii) *Domestic animal breeds present* (n^0); iii) *Ratio of autochthonous breeds*

to those breeds present; iv) *Cultivated species present* > 5% UAS-Useful Agrarian Surface (n°); v) *Non cultivated grass species most consumed by the animals* (n°); vi) *Woody species* (trees and shrubs) *present* (n°); vii) *Managed agro-ecosystems* (productive activities) *in the unit of production* (n°); and viii) *presence (%) of undesirable plant species*.

Final comments

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 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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