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SUMMARY – The SAFE project aims at defining sustainability indicators at the plot, farm and landscape (region or country) levels. It is based on a hierarchical framework that defines step-by-step sustainable agriculture, by selection of principles, criteria, indicators and reference values. Functions of the agro-ecosystem are defined and used for the formulation of principles. These functions are not restricted to production; the agro-ecosystem fulfils several other functions that together concern the three pillars of sustainability: environmental, economic and social. Criteria are specific objectives, more concrete than principles. Indicators are assessed in relation to criteria. Reference values, defined for appropriate indicators, provide a way to define the goal of sustainability. The final set of indicators should provide a representative picture of the sustainability of agricultural systems. The step-by-step definition of sustainability and the strong theoretical basis of each concept would ensure a broadly applicable system that could be used by several actors: farmers, farmer advisers, researchers and decision makers.

Key words : Sustainable agriculture, indicators, framework.

RESUME – *"Idées préliminaires sur le développement d'une structure pour évaluer les niveaux de durabilité dans les systèmes agricoles (SAFE)". Le projet SAFE définit des indicateurs de durabilité aux niveaux de la parcelle, de la ferme et du paysage (région ou pays). Un cadre hiérarchique définit pas à pas l'agriculture durable par la sélection de principes, critères, indicateurs et valeurs de référence. Les fonctions de l'agro-écosystème sont définies et utilisées pour la formulation des principes. Ces fonctions concernent les trois piliers de la durabilité : environnemental, économique et social. Les critères sont des objectifs spécifiques, plus concrets que les principes. Les indicateurs sont établis par rapport aux critères. Les valeurs de référence définies pour les indicateurs respectifs, sont une façon de concrétiser l'objectif de durabilité. L'ensemble final des indicateurs doit fournir une image représentative de la durabilité du système agricole. La définition par étapes de la durabilité et les bases théoriques solides de chaque concept devraient assurer un système d'évaluation largement applicable et utilisable par de nombreux acteurs : agriculteurs, conseillers, chercheurs et preneurs de décisions.*

Mots-clés : *Agriculture durable, indicateurs, cadre d'évaluation.*

Introduction

Sustainable agriculture is the management and utilization of the agricultural ecosystem in a way that maintains its biological diversity, productivity, regeneration capacity, vitality, and ability to function, so that it can fulfil –today and in the future– significant ecological, economic and social functions at the local, national and global levels and does not harm other ecosystems (Lewandowski *et al.,* 1999).

The sustainability of European farming systems is currently under debate. There is indeed a strong

concern that the intensification of agriculture on one hand and the abandonment of marginal areas on the other hand, have long-term consequences for the quality of the environment. The profitability and thus the viability of an important proportion of farms are threatened as well. As a consequence, the number of farms is still decreasing very fast which has important effects upon employment. Sustainability should thus be regarded in the future as an indispensable property of agricultural systems.

Both at the national and international levels, several organisations are analysing and testing sets of agri-environmental indicators, e.g. France IFEN (Piveteau, 1998), US National Research Council (NRC, 2000), ECNC (Elisa project; Wascher, 2000) (EnRisk; Delbaere, 2002), OECD (Environmental Indicators for Agriculture; OECD, 2001), European Commission (IRENA; de Angelis, 2002), or sustainable agriculture indicators, e.g. UK MAFF (MAFF, 2000).

The SAFE project suggests a holistic approach to deal with sustainability in agriculture by defining a coherent analytical framework, which integrates all factors influencing and influenced by agriculture. The proposed analytical framework is not intended to find a common solution for sustainability in agriculture, but to suggest a management tool for the identification, development and evaluation of locally more appropriate agricultural systems and techniques.

SAFE is different from other existing projects because: (i) it does not deal with the national level only, which is the case for many international systems, but it also aims to define indicators for plot and farm levels; (ii) indicators for assessing alternative agricultural practices will be taken into account; and (iii) it is a multi-usage system intended for farmers, farmer's advisers, researchers and decision makers.

Hierarchical framework structure

The SAFE hierarchical framework describes hierarchical levels to facilitate the formulation of a set of sustainability indicators in a consistent and coherent way. The structure of the hierarchical framework is shown in Fig. 1. The objective of the framework is to evaluate sustainability in agriculture by selection of principles, criteria, indicators and reference values. In this hierarchical framework, functions of the agro-ecosystem are defined and used for the formulation of principles. These functions of the agro-ecosystem are not restricted to production. The agro-ecosystem fulfils several other functions and its multifunctional character concerns the three pillars of sustainability: environmental, economic and social. These three pillars are considered equally important in the project.

Principles are general conditions for achieving sustainability. Principles are associated to the diverse functions performed by the agro-ecosystem and they have the character of an objective to be achieved (e.g.: Soil regulation function of the agro-ecosystem shall be maintained or enhanced).

A criterion is the resulting state or aspect of the agro-ecosystem when the principle related to it is respected. Criteria are specific objectives, more concrete than principles, and therefore easier to assess and to link indicators to (e.g.: Soil loss is minimised). The selection of criteria is based on the knowledge of the system to study. They are defined by taking into account the broader conditions of the area where the framework is to be applied. The formulation of a criterion must allow a verdict (Yes/No) on the compliance with the criterion in an actual situation.

An indicator is a quantitative or qualitative variable, which can be assessed in relation to a criterion. It describes, in an objectively verifiable way, features of the agro-ecosystem or elements of prevailing policy, management conditions and human driven processes indicative of the state of the system (e.g.: Water erosion is minimal). A set of indicators should provide a representative picture of the sustainability of agricultural systems in their environmental, economic and social dimensions.

Reference values defined for appropriate indicators, provide a way to define the goal of sustainability. Their aim is to facilitate the evaluation of the degree of achievement of criteria or principle requirements by comparing the actual value of an indicator with the reference value. The formulation of reference values is established on a scientific or empirical basis.

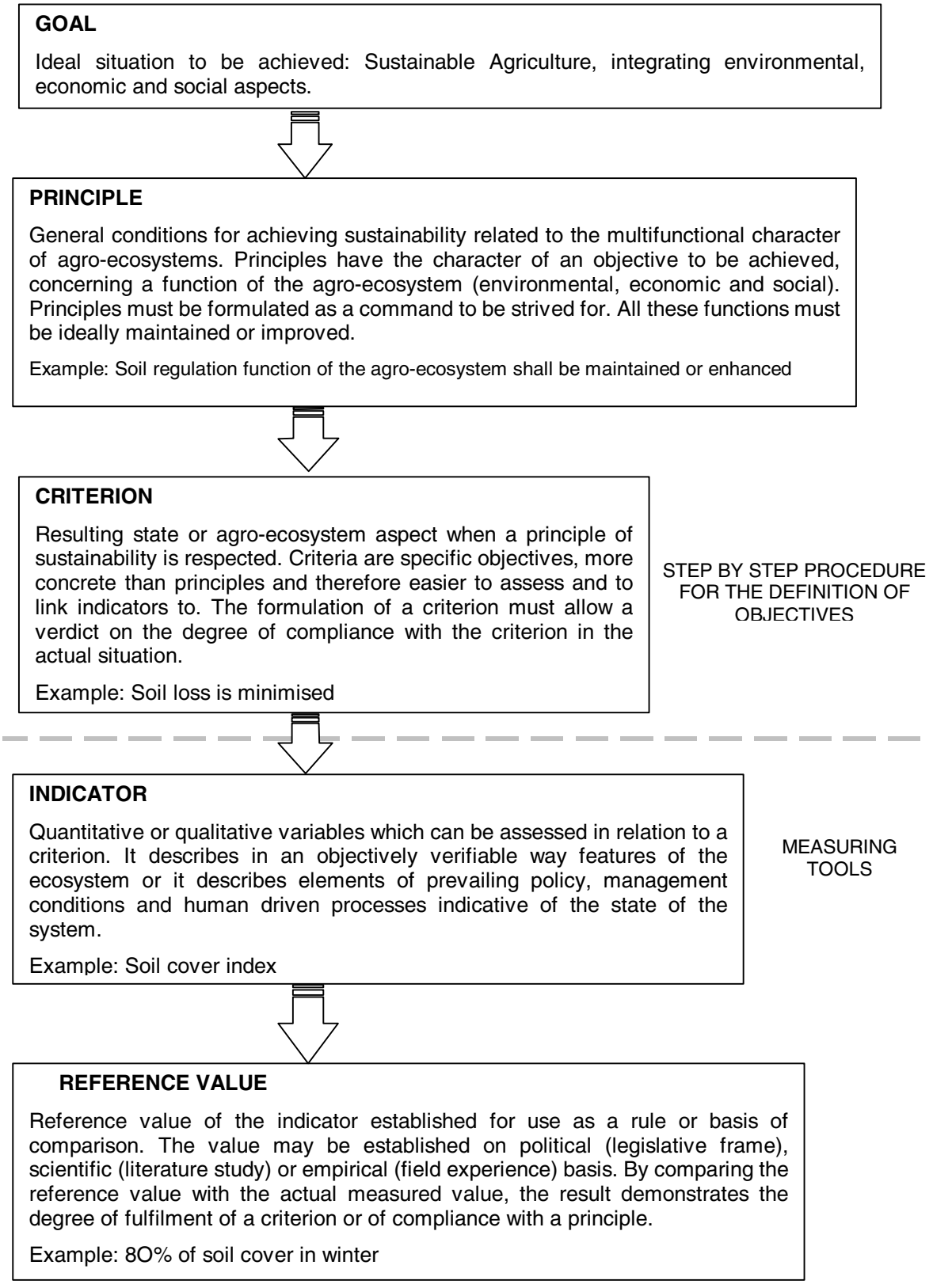

Fig. 1. Hierarchical framework structure (Adapted from Lammerts van Bueren and Blom, 1997).

A provisional list of functions of the agro-ecosystem, principles and criteria is provided in Table 1. It is structured in three parts corresponding to the three sustainability pillars. In the environmental pillar, each function and principle is related to a natural resource: air, soil, water, energy or biodiversity. The principles are expressed either in terms of the regulation of the quantity or quality of the resource (e.g. soil) or in terms of the supply of a given resource of appropriate quality and in sufficient quantity (e.g. water). Biodiversity is divided into two aspects: biotic resources and habitats. There is only one function (principle) in the economic pillar it is related with the profitability and thus the viability of the farms. In the sociological pillar, functions (principles) are clustered in four main challenges: food security and safety, quality of life, social acceptability and cultural acceptability. For each function and principle, one or several criteria are defined. They correspond to a more concrete definition of sustainable agriculture than the principles. They are the basis for the definition of indicators.

Table 1. List of functions of the agro-ecosystem, principles and criteria

	Principles	Criteria
ENVIRONMENTAL PILLAR		
Air	Supply of quality air function of the agro-ecosystem shall be maintained or enhanced	Greenhouse gases emission is minimized Acidifying and eutrophying pollutants emission is minimized Ecotoxic pollutants emission is minimized
	Wind regulation function of the agro-ecosystem shall be maintained or enhanced	Wind speed is adequately buffered
Soil	Soil regulation function of the agro-ecosystem shall be maintained or enhanced	Soil loss is minimized Soil chemical quality is maintained or increased Soil physical quality is maintained or increased
Water	Supply of water function of the agro-ecosystem shall be maintained or enhanced	Adequate amount of surface water is supplied Adequate amount of soil moisture is supplied Adequate amount of ground water is supplied
	Supply of quality water function of the agro-ecosystem shall be maintained or enhanced	Surface water of adequate quality is supplied Soil water of adequate quality is supplied Groundwater of adequate quality is supplied
	Flooding and run-off regulation function of the agro-ecosystem shall be maintained or enhanced	Surface water flow is adequately buffered
Energy	Supply of energy function of the agro-ecosystem shall be maintained or enhanced	Energy production is maintained or increased
	Energy flow regulation function of the agro-ecosystem shall be maintained or enhanced	Energy consumption is adequate Control of energy by the agro-ecosystem is maximal
Biodiversity		
a. Biotic resources	Supply of biotic resources function of the agro-ecosystem shall be maintained or enhanced	Agricultural biodiversity is maintained or increased Para-agricultural biodiversity is maintained or increased Extra-agricultural biodiversity is maintained or increased Biomass of negative para-agricultural biodiversity is minimized Biomass of positive para-agricultural biodiversity is maximized
	Supply of quality biotic resources function of the agro-ecosystem shall be maintained or enhanced	Ecosystem processes supported by living organisms are enhanced Ecosystem stability supported by living organisms is enhanced
b. Habitats	Supply of habitat function of the agro-ecosystem shall be maintained or enhanced	Diversity, number and size of habitats is maintained or increased
	Supply of quality habitat function of the agro-ecosystem shall be maintained or enhanced	Functional quality of habitats is maintained or increased Connectivity between habitats is maintained or increased

Table 1.(Cont.)

ECONOMIC PILLAR		
Viability	Economic function of the agro-ecosystem shall be maintained or enhanced	Farm income is ensured Dependency on direct and indirect subsidies is minimized Dependency on external finance is optimal Agricultural activities are economically efficient Agricultural activities are technically efficient Marketing activities are optimal Farmer's professional training is optimal Inter-generational continuation of farming activity is ensured
SOCIAL PILLAR		
Food security and safety	Production function of the agro-ecosystem shall be maintained or enhanced	Production capacity is compatible with society's demand for food Quality of food and raw materials is increased Diversity of food and raw materials is increased Adequate amount of agricultural land is maintained
Quality of life	Physical well-being of the farming community function of the agro-ecosystem shall be maintained or enhanced	Labour conditions are optimal Health of the farming community is acceptable
	Psychological well-being of the farming community function of the agro-ecosystem shall be maintained or enhanced	Education of farmers and farm workers is optimal Equality in the man-woman relation is acceptable Family access to and use of social infrastructures and services is acceptable Family access to and participation in local activities is acceptable Family integration in the society is acceptable Farmer's feeling of independence is satisfactory
Social acceptability	Well-being of the society function of the agro-ecosystem shall be maintained or enhanced	Amenities are maintained or increased Pollution levels are reduced Production methods are acceptable Quality taste of food is increased
Cultural acceptability	Information function of the agro-ecosystem shall be maintained or enhanced	Educational value features are maintained or increased Scientific value features are maintained or increased Cultural heritage value features are maintained or increased Spiritual heritage value features are maintained or increased

One or several indicators will be defined for each criterion. They will be tested on the basis of different conditions: responsiveness, analytical soundness, measurability, relevance to sustainability issues, ease for interpretation, cost and time efficiency, policy-relevance. A coherent set of indicators will be produced at the end of the project.

The validity of a sustainability indicator depends also on the quality of the chosen reference values (Wefering *et al.*, 2000). Diversity of sustainability indicators in the SAFE project makes it necessary to apply different evaluation strategies: absolute or relative (von Wirén–Lehr, 2001). Absolute evaluation relies on the existence of previously defined reference values. Relative evaluation is based on the comparison of different systems among themselves or with selected reference systems. Consequently, the type of the target value must reflect the specific character of a particular indicator. In the SAFE project, three main types of reference values may be defined: (i) fixed value; (ii) regional or group average; (iii) trend.

Fixed values are represented by scientific or legislative reference values. Scientific reference values are formulated on a pure scientific or technical basis. They may be used for various environmental indicators, for example to determine the minimum percentage of the farm area devoted to the ecological infrastructure or ranges for nutrient content in soil. Legislative fixed values can be called "norms" and are the result of negotiations, for instance between policy makers, farmers' representatives, advisory services and scientists. They need to comply with legal regulations for the area. Fixed values can also be divided into target or threshold values. Target values identify desirable

conditions (Mitchell *et al.*, 1995). Threshold values may be expressed either as minimum or maximum levels or ranges of acceptable values, which should not be exceeded. Both target and thresholds values can have a scientific source. Legislative "norms" are represented mainly by thresholds.

For some indicators it is meaningless to define fixed values. The most adequate reference value established for them is a regional average. Such an average may be particularly suitable for economic indicators (e.g. gross margin for a crop).

Another type of a reference value enables an assessment of a desirable trend in indicators. Assessing changes in time may be achieved by presenting the values of an indicator for the previous years on the same site as a basis for comparison. Trends may be used to describe for example insect or plant diversity.

All the above-mentioned types of indicators and reference values may be applicable to different scale levels (plot, farm, landscape/region).

Conclusions

The development of the SAFE project would provide a coherent set of sustainable farming indicators. The step by step definition of sustainability and the strong theoretical basis of each concept would ensure a broadly applicable system that could be used at the plot, farm, landscape (region or country) levels by different actors: farmers, farmer advisers, researchers and decision makers. An attempt will be made to define reference values for each indicator.

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