Framework for measuring sustainability in dairy farming

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1. Introduction

The prospects for agriculture are not clear. Factors from within agriculture as well as factors from outside the sector influence its future. The key word, when addressing future possibilities for agriculture by the government, agricultural organizations and society is sustainability.

If dairy farming is to become more sustainable, there must be an effective method of monitoring trends in sustainability (Mitchell et al., 1995). Therefore sustainability has to be made operational in each specific context at scales relevant for its achievement and appropriate methods must be designed for its long-term measurement (Heinen, 1994). A strategy for reaching sustainability in dairy farming should be able to consider all possible activities and all their side effects (Bosshard, 2000; De Graaf et al., 1996). Therefore a system approach is most appropriate to measure sustainability (Kristensen and Halberg, 1997). Despite many efforts no appropriate method exists which measures sustainability in dairy farming. The aim of this paper is to design a framework that measures the sustainability in dairy farming. By means of this framework different dairy-farming systems (represented by experimental farms) can be compared on their sustainability.

Following this introduction, section 2 clarifies several definitions on sustainability. In section 3 methodology to measure sustainability in dairy farming is explained.

2. Definition of sustainability

During the last decade, sustainability has been on the agenda of many agricultural scientists. The two most popular and widely used definitions of sustainability (Mitchell et al., 1995) are given in Our Common Future (Brundtland, 1987) and in Caring for the Earth (IUCN, 1991). These are respectively: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"; and "development that improves the quality of human life while living within the carrying capacity of supporting ecosystems". Such broad definitions are likely to give rise to various different interpretations (Callens and Tyteca, 1999; Bell and Morse, 1999).

This diversity in the definition of sustainability is among others due to:

a) The time period in which is used
b) The context in which sustainability is used
c) The position and opinion of the user

ad a) Perceptions on sustainability of different interest groups change over time (Shearman, 1990). As a consequence sustainability does not represent the endpoint of a process; rather it represents the process itself (Shearman, 1990; WRR, 1995). Sustainability implies an ongoing dynamic development, driven by human expectations about future opportunities. Sustainability is "sustainable development" (Bossel, 1999). Therefore sustainability is only meaningful if it is based on a trend over time (Bell and Morse, 1999). A framework for measuring sustainability in dairy farming will have to be revised in time. In this way new scientific understandings can be included in the framework. Trends in sustainability of dairy farming can be analyzed by comparing results on sustainability criteria over several years.

ad b) The meaning of sustainability is associated with the different contexts in which it is used (Shearman, 1990). Different scales can be distinguished: farm, village, town or city, region, country and so on until the whole planet is considered (Niu et al., 1993). From a theoretical perspective the spatial scale is clearly very important when one attempts to put sustainability into practice or when one judges the level of sustainability of an existing system (Bell and Morse, 1999). As the framework for sustainability is designed to compare different dairy farming systems, sustainability will be represented at farm level in this paper.

ad c) Sustainability means also different things to different people (Shearman, 1990; Kelly, 1998; Lowrence et al., 1986; Heinen, 1994). People tend to underestimate things that are not in their own direct, immediate interest, and so ignore some of the most pressing global problems related to sustainable development (Mitchell et al., 1995). The term sustainability has therefore a different meaning for a farmer considering his possibilities to continue on his farm than for an environmentalist looking at the farm from outside (Kristensen and Halberg, 1997). Even between farmers different approaches towards sustainability exist. These different approaches can be recognized in the personal approach towards their way of living and farming, the so-called "farming styles" (Van der Ploeg, 1994).

3. Methodology

As mentioned above much variation appears in the definition of sustainability. In this article a design is chosen which takes this variation into account. In this design three steps can be distinguished:

1. Determine all possible criteria which are related to sustainability in dairy farming
2. Select relevant sustainability criteria
3. Weighing all relevant criteria into an overall sustainability-index

Step 1 is described in paragraph 3.1. Subsequently steps two en three are described in paragraph 3.2 and 3.3.

3.1 Determination of all possible sustainability criteria

Sustainability is subdivided in three areas: economic, social and ecological sustainability (Chandre Gowda and Jayaramaiah, 1998; Cornelissen et al., 2000; Østergaard). Economic sustainability is regarded as ability of the dairy farmer to continue his farm on the short and long term (economic viability). Economic viability can be defined as ability of a farm to survive in the political, social and economic environment (Turner and Taylor, 1998). Economic sustainability is mainly important to dairy farmers. Social sustainability relates to a new political situation that is emerging in the agro-food sector as society becomes increasingly concerned about the impact of agriculture on the well being of people. Issues such as food safety and quality and ethically appropriate methods of production are gaining greater attention (Blandford and Fulponi, 1999). Ecological sustainability concerns the threatening of the flora, fauna, soil, water and climate. The Brundtland report (1987) underlines the fact that sustainable development also requires a production system, which respects the commitment to preserve the ecological basis for development

Within the three areas of sustainability (economic, social and ecological) different sustainability aspects can be distinguished. These aspects consist of one or more criteria. These criteria will be measured directly or indirectly by means of one or more indicators. First a gross list with all possible sustainability aspects and criteria within each area of sustainability is designed with the help of several farm-oriented experts. An overview of the determined aspects and criteria is given in appendix A.

However the definition of sustainability in dairy farming is dependent on knowledge, the position and the perception of each individual. Therefore consumer organizations, environmental groups, farmers and scientist will be asked by means of a questionnaire to establish the criteria they associate with sustainability of dairy farming. Three different questionnaires will be used: an economic, social and ecological questionnaire. The questionnaire on economic sustainability will be send to farmers and economic experts. The questionnaire on social sustainability will be send to consumer organizations, farmers and social experts, the questionnaire on ecological sustainability will be send to environmental and nature groups, farmers and ecological experts. In this way different interest groups with different perception and position have the opportunity to indicate which aspects and criteria they think are important towards sustainability in dairy farming. Advantage of this approach is that the designed sustainability framework is broadly based, which is prerequisite for implementation (De Graaf et al., 1996).

3.2 Select relevant sustainability criteria

As a result of the chosen approach in paragraph 3.1 many sustainability criteria will be introduced. It is however not possible to include all these sustainability criteria, as the framework of sustainability faces the risk of being too complex and data intensive. To select the most important criteria, relevancy of sustainability criteria will be rated. In Churchill (1999) a method, called equal-appearing intervals, is proposed to select a subset of criteria. In this method experts are asked to evaluate a criterion on its own merits. The criteria are placed on a scale varying form favorable to unfavorable in 11 classes. For each criterion an average score (scale value) is calculated. The "Q value" is the interquartile range, which provides the variation. It is possible that several criteria have approximately equal scale values. It is however preferred that selected criteria are interpreted consistently by those responding. Large values of Q indicate that there was a wide disagreement among the experts as to the degree of favorableness expressed in the criterion, and, therefore the criterion is ambiguous. Given that two criteria have approximately equal values, the one that has the smallest Q is preferred (Churchill, 1999).

Therefore consumer organizations, environmental and nature groups, farmers and scientist will be asked, by means of a questionnaire, to score all the criteria on a scale of favorableness in the context of sustainability in dairy farming. In this way the most important sustainability criteria for each area of sustainability will be selected.

3.3 Weighing all relevant criteria into an overall sustainability-index

It is impossible to assess unambiguously whether development of an agricultural production system is two-valued: sustainable or unsustainable. Two-valued logic, therefore, yields an unsatisfactory conclusion (Fresco and Kroonenberg, 1992; Pelt et al., 1995). In other words: sustainability is a continuous concept (De Wit et al., 1995).

For measuring sustainability the following two steps can be distinguished: (1) represent all criteria on the same scale and (2) weigh all criteria into an index on sustainability in dairy farming. By using these steps sustainability of dairy farms can be expressed on a continuos index on sustainability in dairy farming. In paragraph 3.3.1 it is described how all criteria are represented on the same scale. Subsequently in paragraph 3.3.2 it is explained how all criteria are weighed into an index. In paragraph 3.3.3 conjoint analysis, which is used for representing criteria on the same scale and weighing criteria into an index, is discussed.

3.3.1 Represent criteria on the same scale

Utility reflects the level of preference or enjoyment attached to a good (Barry et al., 1995). In this paper utility corresponds with sustainability. By means of utility functions physical data have to be converted into utility values. In this way all sustainability criteria are expressed on the same scale. As a result all criteria can be integrated into a sustainability index.

The shape of the utility function might however vary. Graph 1 in figure 1shows an inverse relationship between a sustainability criterion (concentration of pollutant) and the utility associated with it, so that as pollution increases utility decreases.

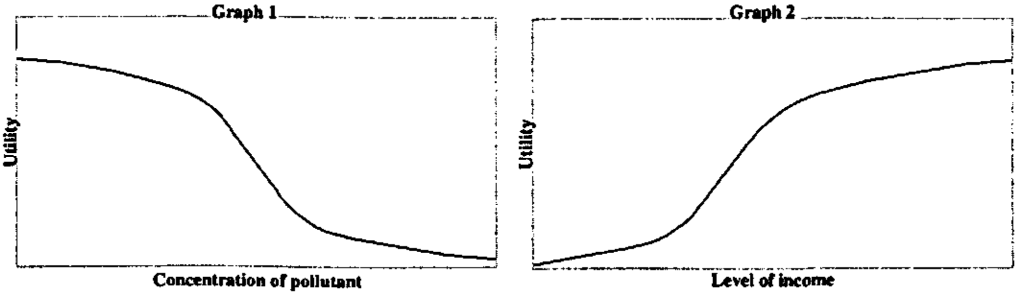

Figure 1 Examples of functions for converting parameters expressed in physical units into utility terms

This relationship, as graph 1 shows, is not linear, since it is assumed that the level of pollution has no negative effects on the environment, as long as the pollution level is limited. As the pollutant concentration increases, the quality of the environment worsens, at first quite slowly and then even more rapidly. Graph 2 in figure 1 shows that utility increase when income increases, but again the relationship is not linear. Given the relationship between physical and utility values is very seldom linear, it is necessary to define utility functions for each sustainability criterion.

It is of course an interesting question how utility functions can be assessed. Clearly utility functions have to be based on solid scientific research. This means that scientific information and expert opinion are of critical importance. However in certain areas and under certain circumstances, different experts and decision-makers may have different views on the shape of the utility function. Besides for some criteria perception of consumer organizations and other interest groups is more important for the assessment of utility functions then expert knowledge and scientific research. In both cases it is however important to measure the perception of different respondents. Conjoint analysis is an adequate method to measure perceptions (Vriens, 1994).

3.3.2 Weighing criteria into a sustainability index

The goal of this research is to compare different dairy farming systems on their sustainability. For this goal importance ratings of each criterion have to be determined, in this way all sustainability criteria can be summed up to one sustainability index. However it is sometimes difficult to reach a general agreement about weights, since costs and benefits are often unequally distributed among groups and every group tends to give higher importance to its own costs and benefits than to the ones of other groups. Groups that have economic benefits from a polluting productive activity, for instance give a relatively high importance to economic aspects, especially if they do not suffer from the impact of the pollution they cause. Vice versa, residents tend to attribute a relatively high importance to the quality of environment, especially if they do not benefit from the productive activity. Therefore it is not possible to set up a system of weights that could be generally applied (Andreoli and Tellarini, 2000). Therefore the separate sustainability criteria of the three areas (economic, social and ecological) will be weighed in first. This means that three separate sustainability indices will be designed to evaluate dairy farms on sustainability. Nevertheless these three sustainability indices are still being weighed in a general sustainability index, as it is interesting to know how different interest groups weigh these three sustainability indices in the overall sustainability index.

For each area of sustainability (economic, social and ecological) criteria are weighed into an index. Importance ratings of each criterion are dependent on perception of different interest groups. Therefore perception of different interest groups on sustainability is measured. As mentioned before conjoint analysis is an adequate method for measuring perceptions (Vriens, 1994). This method will be explained in paragraph 3.3.3.

3.3.3 Conjoint analysis

Conjoint analysis was developed from the theoretical work of mathematical psychologists (Luce and Tuckey, 1964) and is commonly used in marketing research (Cattin and Wittink, 1982) for measuring buyers' trade-offs among multi-attributed products and services. In conjoint analysis products or services are defined by a number of relevant attributes or characteristics each with a limited number of levels. These products, called profiles, have to be evaluated by respondents, who have to rank or rate them or choose their most preferred ones from smaller choice (Haaijer, 1999). In this way utility functions and importance ratings of each attribute (part-worths) can be determined. Two basic assumptions for conjoint analysis are: 1) a product can be described according to levels of a set of attributes and 2) the interest group's overall judgement with respect to that product is based on these attribute levels (Steenkamp, 1987). Sustainability can be described according to levels of a set of attributes (criteria). Therefore conjoint analysis is an appropriate method to measure perceptions on sustainability.

Srinisavan and Park (1997) developed a new approach in conjoint analysis, called customized conjoint analysis (CCA), that combines the self –explicated approach with aspects of the full-profile approach. This approach has as main advantage that in comparison with other conjoint analysis techniques many attributes can be analyzed. In the self-explicated approach the respondent first evaluates the levels of each attribute. The respondent may evaluate these levels by rating the desirability of the levels (e.g. on a 0-10 desirability scale). Next, the respondent is asked to indicate the relative importance of each of the included attributes. In the self-explicated approach utility functions and importance ratings for all attributes are obtained. As however it is expected that utility functions and importance ratings are estimated less accurately by using the self-explicated approach, the proposed approach involves conducting a full profile conjoint analysis. By using the self-explicated approach the most important attributes (6-9 denoted as core attributes) are selected. Note that the set of core attributes, in general, will differ across respondents. The proposed full-profile conjoint analysis is customized to the respondent's core attributes thereby estimating the utility functions and importance ratings. In the full-profile method respondents are asked to evaluate (rank order, rate, etc) a set of hypothetical objects that differ from one another on two or more attributes and that are defined on all attributes which are included in the study. The utility functions and importance ratings of core attributes are calculated by using the self-explicated approach and the full-profile approach. The utility functions and importance ratings of the remaining attributes are calculated by using the self-explicated approach.

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Appendix A

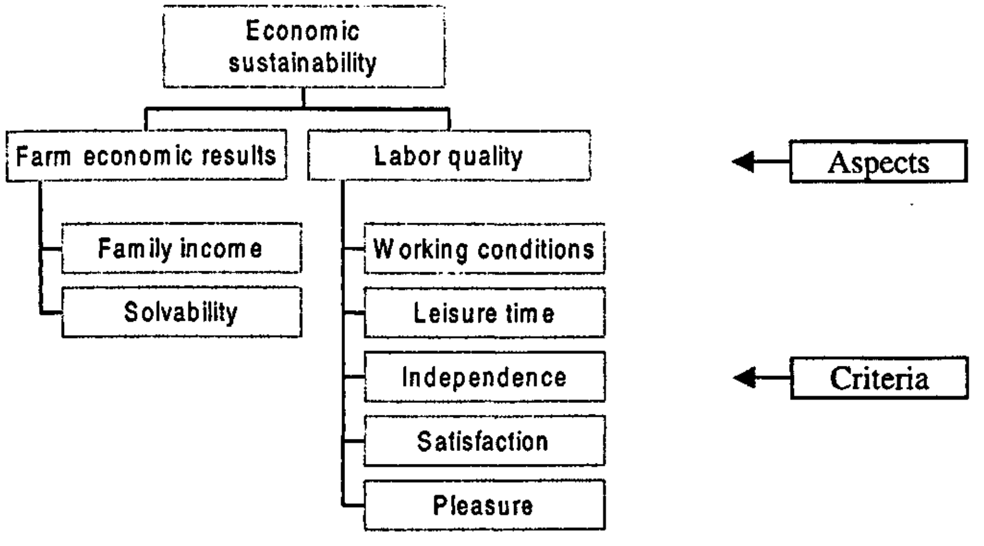

Figure 1 Economic sustainability framework of a dairy farm

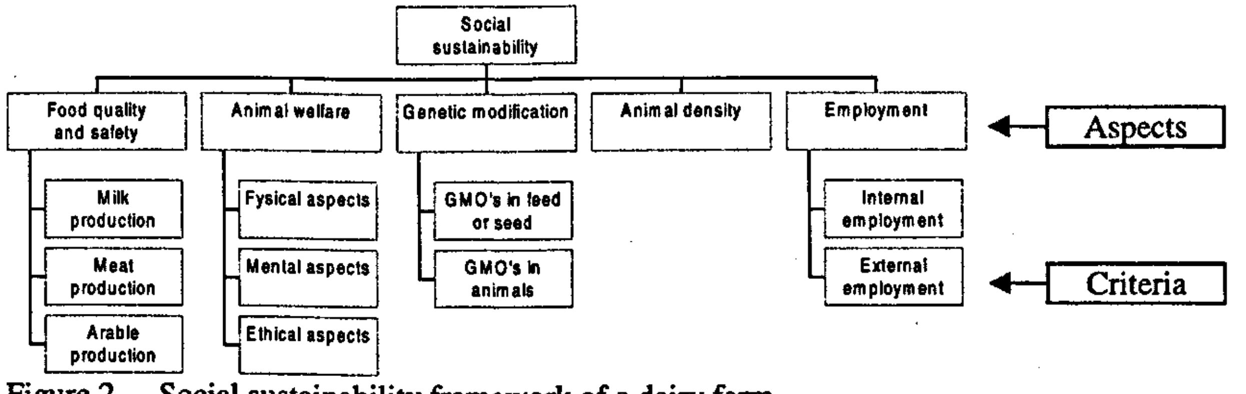

Figure 2 Social sustainability framework of a dairy farm

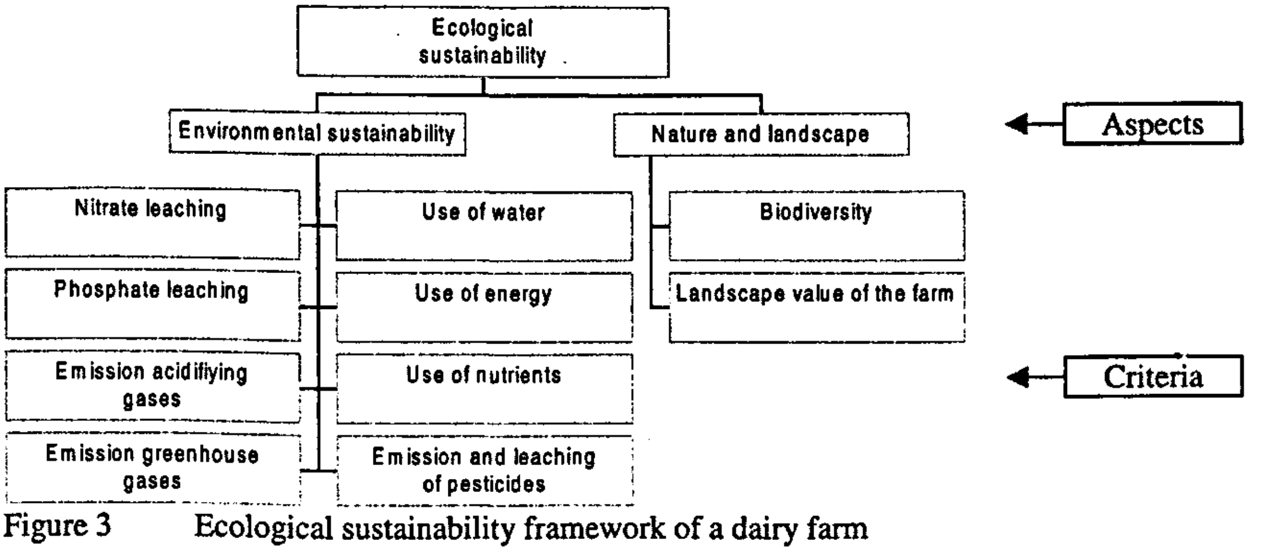

Figure 3 Ecological sustainability framework of a dairy farm