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A systems approach for assessing sustainability in livestock farms

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Summary

The concept of sustainability is widely used in agriculture. There is, however, a large variability in the interpretation of the meaning of sustainability. The broad understanding in conjunction with the complexity of livestock farming calls for a systems approach.

In this paper different interpretation of sustainable agriculture is described and discussed. It is concluded that sustainable agriculture has a major normative dimension and obviously has different meanings for different groups in society. Using sustainability in a systems describing concept, one has to be very aware of the normative dimension.

With a starting point in farm models previously described in this journal a model is introduced where the farm is shown in the centre and put into perspective with other groups in the whole society. The other group represents different perceptions of sustainable agriculture. These perceptions might be in conflict with each other and/or with the observed farm. The idea is then to analyse and forecast in which direction the dominant perception of sustainability will be moving. It is suggested that this can be analysed be means of the discourse concepts, which come from social science.

A key point in the model is that the farm is considered as a learning human activity system where the farmer reconsiders or reflects his current management in the light of the change in society. In Denmark the dominant perception of agricultural sustainability has changed towards the environmental issues during the last 20 years. As a consequence of this change different indicators have been developed for the purpose of describing and stimulating self reflection concerning environmental issues at farm level. These environmental indicators are presented and discussed through examples. Finally, an approach of including a variety of productions systems (i.e. both conventional and organic farming systems) in conjunction with researchers from a variety of disciplines is described.

Introduction

During the last decade, sustainability has been on the agenda for many agricultural scientists. However, although the concepts of sustainability is widely used in agriculture there appears to be a large variability in the interpretation of the meaning of sustainability - also within animal production systems (Zijpp, 1993). Dunlap et al. (1992) have made an empirical examination of the understanding of sustainable agriculture among faculties and farmers in US, which shows a large variation of the understanding, in particular within the academic disciplines and between faculties and farmers.

The broad understanding in conjunction with the complexity of livestock farming calls for a systems approach for assessing the sustainability of livestock farms. In this paper sustainable agriculture is discussed with a starting point in farm models previously described in this journal. We are discussing the possibilities (or lack of possibilities) of making precise judgements as to whether a particular farming system is sustainable or not using different interpretations of the concept of "sustainability". Using examples from Danish agriculture and society we suggest how the sustainability at livestock farms might be assessed and further developed.

Interpretation of sustainable agriculture

Prior to the late 1970's the concept of sustainable agriculture was confirmed to few groups and organisations of alternative agriculture, i.e. organic movements (Buttel, 1993).

Increasingly, the environmental movements began to see the agricultural sector as being crucial for the environment. Environmental attention to agriculture began to accelerate during the 1980's both in US (Beus & Dunlap, 1990) and in EU (Michelsen, 1994).

The 1980's was also the decade when there were problems with overproduction and collapse of the export market. This led in US to a significant growth in farmers' interest in sustainable agriculture in terms of Low Input Sustainable Agriculture (LISA, Beus & Dunlap 1990). Also in EU there was a growing interest among farmers for sustainable agriculture although it started a few years later than in US.

Later in the 1980's, the debate about sustainable agriculture was highly stimulated by the so called Bruntland Report (1987 p43): "A sustainable development is a development that meets the needs of the present generations without compromising the ability of future generations to meet their own needs".

There seems, however, to be major differences in the perception and understanding of what sustainable agriculture means. Based on a literature review, Douglass (1984) discerned between three different cases in which the term sustainable agriculture had been used:

1) Long term food sufficiency either domestic or world wide (food sufficiency).
2) An agricultural system which preserves and conserves renewable and non-renewable resources (stewardship).
3) A set of agricultural practices, which encourages certain virtues and undergirds the vitality of local communities to be preserved or reinstated (alternative agriculture).

According to Ruttan (1994) view 1) represents the mainstream agricultural community and economists. View 2) might represent the perspective of environmentalists and view 3) represents the perspectives of alternative agricultural groups like organic or biodynamic farmers.

Burkhardt (1989) discusses the morality behind sustainability with a starting point in the above mentioned perspectives. His conclusion is "that our obligations to future generations entail sustaining more than just sufficient food production or an adequate resource base. Sustainability has to do with larger institutional issues, including our ability to incorporate our common morality democratically into our institutions, practices and technologies".

Thompson (1992) argues that some common discrepancies between different notions of sustainability are related to the indiscriminate use of sustainability as 1) "a system describing concept" or 2) "a goal describing concept". He claims that, even when position 1 is taken, one should be very aware that a judgement of the sustainability of a system is in fact a normative claim. This is because the choice of indicators of sustainability itself is based on value judgements. Within position 2) Thompson discusses the problem of considering sustainability as an intrinsic value. Goals that are intrinsically valuable are goals that require no further justification. They are ends in themselves. Thompson (1992) found, however, that sustainability should not be considered as an intrinsic goal because one can suggest systems that one would not wish should last for ever (i.e. societies based on slavery). Therefore, he concludes, sustainability should be used as an add-on goal for systems that meet other desirable objectives.

In another paper Thompson (1997) discusses the varieties of sustainability with a starting point in the above mentioned perspective. He finds that the basic idea behind food sufficiency (perspective 1) is fundamentally different from the idea behind perspective 2 and 3. While food sufficiency is a matter of input/output relationship (resource sufficiency) the stewardship and alternative agriculture viewpoints are matters of reproduction of crucial elements in the system (Thompson, 1997). Thompson denotes this aspect as "functional integrity" and points out that the difference between environmentalists' and alternative agriculturalists' viewpoints relates to the different systems and systems attitudes on which they focus.

Thus, the term sustainability obviously has a different meaning for a farmer considering his possibilities to continue on his farm than for an environmentalist looking at the farm from outside or someone focusing on intensive farming systems in relation to other parts of society. Therefore, someone using sustainability as a system describing concept should be very careful to define that system, its borders and its interaction with the outside. Next, one has to be very explicit with defining whose goals or interests would be compromised if the system is not sustainable. This way it might be easier to agree on and understand the purpose of selected indicators of the (non)-sustainability of different farming systems.

Systems approach

Systems theory and systems thinking give a general framework for the understanding and the communication of complex phenomena and problems seen in the real world. The purpose is to get an understanding of the observed system as a whole, through an identification and modelling of the different elements in the system. This implies a reduction and simplification of reality.

A basic motto in systems theory is that "everything is related to everything else". Thus, the reduction and modelling of the observed systems will depend on the eyes that observe reality and can always be discussed. By this, we mean that it is a normative task to define a system's borders and which of its relations to other systems that are important.

Because of their ability to create knowledge about complex problems, systems theory and systems thinking are good tools for assessing sustainability on livestock farms. However, one has to be very aware of the problems of dealing with fundamentally different conceptions of sustainability as mentioned in the previous section. In particular, it can be a problem if the scientist responsible for the system identification and modelling does not acknowledge the normative dimension of sustainability.

When studying agricultural systems, one must not overlook the important role of the farmer/farmer's family, their values and goals and their relations to others (colleagues, advisors etc.). Thus, Le Moigne's (1977) more narrow definition of a system as a goal seeking object is more appropriate when studying agricultural systems: "A system is an object in the surrounding world which guided by goals undertakes an activity and develops its internal structure through time without losing its unique identity" (Le Moigne, 1997, own translation). The importance of this definition is that it describes something that is at the same time active, stable and developing – all in a combined attempt to reach a certain goal (either consciously, instinctively or mechanically). This concept of a system means that the observer has to choose to focus on what the system does (the functional aspect), what the system is (the ontological aspect) or how it develops (the morphogenetic aspect). It is one of the strengths of systems theory to make this unavoidable choice more clear. Moreover, Le Moigne's definition of a system as a unit that seeks to keep its unique identity even if it adapts and undergoes a development, is analogous to Thompson's (1997) concept of functional integrity. Thus Le Moigne's system definition might be a good framework for the analysis of the sustainability of agricultural systems from this point of view.

Sørensen & Kristensen (1992) give a general description of systems thinking and introduce a general model of a farm as a cybernetic system suitable for research. This model has been one of the cornerstones in Danish livestock farming systems research during the last 10 years.

The model of Sørensen & Kristensen (1992) discerned between the production system and the management system, thus acknowledging the idea of a farm as a goal seeking system. The model of the production system was quite simply only including well-known elements such as different crops, animals etc. The management system was introduced as a black box and thereby indicating that no general model was found suitable. The normative part of the management system was not modelled at this stage. This model has mainly been used to study and mimic the production process at private farms. According to the definition given by Bawden et al. (1984) this type of modelling can be classified as hard systems modelling and the normative dimension is only acknowledged through participation of farmers.

In the paper by Gibon et al. (1996) made by 6 scientists from 5 European countries, a common European model of a farm based on systems theory and thinking is introduced. This model includes the essential parts of the model by Sørensen & Kristensen (1992) and at the same time it is more explicit concerning the normative dimension. It represents the duality between the view of a farm as a human activity system (primarily functional and morphogenetic aspects) and the view of the farm as a production process (PP) (primarily ontological aspects).

The view of a farm as a PP focuses on the farm as a biotechnical system transferring physical input to physical output. The PP view gives good possibilities for operationalizing sustainable agriculture parameters concerning productivity and environmental effects of the livestock farm. However, traditionally the PP view has focused on production and output in terms of products and economy while externalities were not included.

In the view of a farm as a human activity system (HAS) the farmer (family) is seen as a person satisfying specific objectives through farming activities. In the HAS view the farmer uses information from the farm environment and the production system to make decisions concerning the biotechnical system in order to adapt the farming activities to his own objectives as well as to respond to pressures from the outside. Thus, the HAS view gives good possibilities for describing and analysing social values concerning sustainable agriculture and the communication process between the farmer and the society concerning adapting and developing sustainable agriculture activities.

The dual view on livestock farming, as in the model by Gibon et al. (1996), implies that sustainability is considered a normative or a goal describing concept. The problems, however, are firstly, whose norms or goals should be aimed at and secondly, how should they be implemented at the farm. As mentioned earlier there might be major differences in the view of what is sustainable or not. A conventional farmer has another view than an alternative farmer who again might have a different view from that of an environmentalist. Scientists, therefore, have to be very aware of which social values and institutional backgrounds their interpretation of sustainable agriculture is based on. This problem is not addressed in the paper by Gibon et al. (1996).

Figure 1 shows a model that represents the dual view of a farm (PP and HAS) in a similar way as in Gibon et al. (1996). The model is, however, extended to include different other groups in society which are supposed to have interests in farming systems, i.e. the market, conventional or organic farmer colleges, public authorities, environmentalists, advisors and farmers. All these groups are expected to have opinions about the meaning of sustainability in agriculture. The inclusion of these groups in the model in figure 1 illustrates the idea that the individual farmer/farmer's family probably does not develop his/its norms and practices (including their reaction to the sustainability issues) isolated from others. Some farmers more easily reflect on and react to changes in values and perceptions in (non-farmer-groups) society, while others to a larger degree conserve their practices and exchange ideas between colleagues (Ploeg, 1990; Le Guen & Ruault, 1994; Noe, 1997). Moreover, analyses using the farming styles concept have demonstrated that farmers, though different, tend to group around certain value orientations (Ploeg, 1996; Noe, 1997).

Even if not all farmers can be expected voluntarily to pay much attention to issues of sustainability it can be argued that it is important for them to adjust at least partly in order to stay in business in the long run. Thus, in figure 1 an arrow around the farm symbolise that the farmer needs to reconsider or reflect his current management in the light of the change in the outside world. This understanding fits well in the theory of 2nd order cybernetics (von Foerster, 1992). A key point in figure 1 is that the farm is considered as a learning human activity system. Inspired by the theory of 2nd order cybernetics Thyssen (1992) writes the following concerning a systems learning process: "It (the system) can observe that it is observed by other subsystems using criteria which are foreign to its own but which affects its autopoiesis. This means that the internal criteria of the subsystem have to be supplemented by external criteria. The result is that the subsystem becomes sensitive to hitherto unforeseen effects of its operations so that it might consider how to relate to e.g. threats of political intervention, scientific analysis of pollution or the consequences of its activities for the local community".

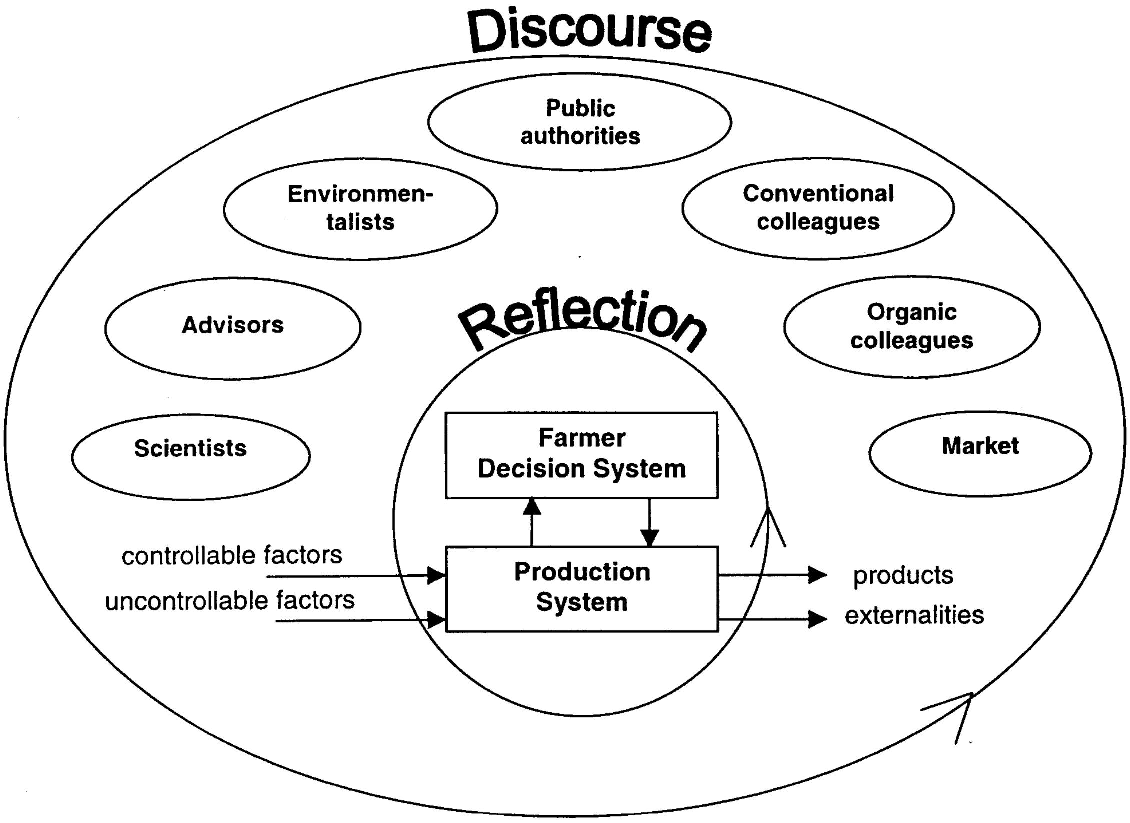

Figure 1. A model of the farmer reflecting on the farm's sustainability in light of the value systems and discourses in society.

As shown in the model (Figure 1) a lot of groups are expected to influence the definitions of sustainability in agriculture. It must be realised that not all groups' perception of sustainable agriculture can be acknowledged since there will be conflicts between groups and some are more dominant than others. A major problem for the scientists as well for the farmers and advisors is to reduce the complexity and be able to forecast the coming dominant perception of sustainability. The next step is to reconsider the current farming activities in the light of this guess.

Changes in the general perception in society can be analysed by means of social science by the so-called discourse concept (Michelsen, 1994). According to encyclopaedia the definition of a discourse is the opposite of intuition, i.e. a logical and coherent thinking involving a development of arguments step-by-step. A discourse is based on values and includes anonymous rules of thinking, definitions of what may be looked upon as problems of interest, distinct institutions and distinct types of practices. By using the discourse concept it is possible to analyse the process which constitute stability and change of society (Michelsen, 1994).

In relation to Figure 1 the agricultural discourse expresses the current value systems including the interpretation and perception of sustainability. The farming community as well as the other groups in the society try to promote their values and perception of sustainability and challenge the dominant discourse. A competition for discursive hegemony is supposed to be going on (Michelsen, 1994).

Changes in society's perception of agricultural values have been a major reason for implementing systems theory in agricultural science in many cases (Bawden et al., 1984; Scholl & Holt, 1990; Thompson, 1997; 5 cases in Gibon et al., 1996). The argument has been the need of a tool to deal with the increased complexity due to these changes. The normative dimension of agricultural research is therefore acknowledged. However, only few scientists has described how to handle and reduce this complexity in a way which acknowledged the normative dimension. The discourse concept offer means to do this, but it must be realised that this concept is still very new and therefore relatively untested within agricultural science. However, the discourse concept is not crucial to the model shown in Figure 1. The crucial point is to be aware of the complexity, the conflicting interests and thus the ethical questioning, and the need for forecasting the expected dominant perception of sustainable agriculture, and on this basis, to develop indicators of farming systems performance in the light of new issues.

Assuming that the agricultural discourse (the dominating perception of sustainable agriculture) has changed, the next step is to operationalize and reconsider relevant consequences of the current farming activities. Other important research tasks are the different farmers' possibilities and motivation for developing their farm in accordance with the new issues and with the type of information they need (indicator types etc.). Thus, both the active and the morphogenetic aspects of the management system are relevant for research in sustainable agriculture. The next section gives some examples of operationalizing environmental issues.

Thus the purpose of Figure 1 is threefold:

- to show the potential of systems thinking for dealing with the farm's production and the related externalities in a coherent way,
- to show the need for a tool to describe the farm's sustainability in light of the changed discourse/new values and goals,
- to show the need for researchers to reflect carefully on which aspects of sustainability they should focus.

These aspects will be further described through examples in the next section.

Assessing sustainability in livestock farms - an example from Denmark

Change of agricultural discourse

A change of the agricultural discourse from values concerning economic productivity to environmental issues has occurred in Denmark from 1980 - 1992 (Michelsen, 1994). In 1987, the Danish Parliament set a goal of reducing pollution from Nitrogen (of which agriculture contribute 80%) and pesticides to 50% over 10 years. Thus, when sustainability became a buzz-word in the late 80's regarding agriculture it was in Denmark primarily linked with loss of nitrogen and use of pesticides, (MAF, 1991).

Along the increased focus on nitrogen loss and pesticide use organic agricultural systems have experienced an increased interest.

Before the early 1980's, organic agriculture in Denmark was limited to a few idealistic biodynamic farmers and their organisations. The number of organic farmers increased from 30-100 before 1980 to approx. 1500 in 1997 corresponding to 2% of the agricultural area. Since 1992, the Danish Parliament has considered increased organic food production as a means to reduce environmental problems. One of the latest political initiatives is the so called "Action Plan for Promotion of Organic Food Production in Denmark" by the Ministry of Agriculture and Fishery in 1995. In this plan it is expected that in the year 2000 the proportions of organic food will reach a market share of 15-20% and 7% of the Danish agricultural area (MAF, 1995).

Operationalizing environmental issues for livestock farms

As a consequence of the change in discourse the description of different farming systems solely in the terms of economic performance and production efficiency (for instance kg milk per cow or hkg grain per hectare) has become increasingly insufficient. Different groups of interest outside the agriculture have questioned for instance the nutrient balance and energy efficiency of intensive farming systems under the sustainability heading.

At the Danish Institute of Agricultural Sciences an interdisciplinary research project is aimed at developing indicators for resource use and environmental performance on livestock farms.

The idea was to develop a decision aid for farmers to facilitate the inclusion of these aspects together with animal welfare and social aspects concerning the farm family in the management processes (Sørensen & Sandøe, 1994). The indicators should therefore function as a feedback of information from the production system to the management system in order to stimulate self-reflection. They have thus, been chosen to fulfil certain requirements:

- they should describe and operationalize relevant aspects of farm resource use or environmental impact in a way suitable for use in multiple objective decision making,
- they can be calculated, measured or registered by farmers together with local advisors at a reasonable cost,
- farmers should be able to influence the indicator levels through management practice.

Not all aspects of environmental impact from farming are necessarily relevant for the farm's or even society's sustainability and some aspects are only problematic for society in a broad sense or for very future generations. Therefore, each indicator will be discussed with the farmers as part of an ethical learning process (see self-reflection arrow in figure 1). The issues covered so far in this project and the parameters chosen to operationalize them are shown in table 1 and examples are shown in Table 2.

Fossil energy is a limited resource and its combustion contributes to the atmospheric pollution. Both aspects make it particularly interesting for future generations to know how much energy is used for the current agricultural production. In terms of societal sustainability the question might be phrased: How dependent is our milk production on direct and indirect input of the limited reserve of fossil fuel? Therefore, the use of diesel and electricity for farm machinery and the energy used for production of farm input is calculated according to Halberg et al. (1994).

Nitrogen (N) lost from livestock farms, contribute to ground water pollution and eutrophication of marine waters. Phosphor (P) might be lost to fresh water and is basically a limited non-renewable resource. Therefore, the surplus of N and P is of interest to both now-living and future persons and is calculated according to Halberg et al. (1995).

Other issues operationalized for use in an extended farm account are pesticide use and the room left for wild flora and fauna on the farm (Table 1). These potential impacts on biodiversity and landscapes values have so far been described by the average number of standard pesticide dosages used, the percentages of weeds left in grain crops and the status and extent of small biotopes in percentage of the cropped area (Mayrhofer & Schwaberda, 1991).

Table 1. Indicators of resource use and environmental impact.

Topic	Reason	Indicators	Assumed relative importance for	
			Living generations	Future generations
Area	LR	ha	high	low
Fossil energy use	LR, P	MJ total and per kg milk, meat, grain	low	high
Phosphorus balance	LR, P	P surplus, total, kg per ha, P efficiency	medium	high
Nitrogen loss	P	N surplus, total, kg per ha, N efficiency (N output/ N input)	high	low
Pesticides use	P	Avg. number std. treatments per ha (AST) % untreated area+ +	medium	high
Biodiversity, Landscape	P, LT	% weeds in grain crops, % area with small biotopes, biological infrastructure	high	medium
Soil-structure	LT	Use of heavy machines	medium	high
Soil-fertility	LT	?, to be found	low	high
	P	Cu surplus, kg per ha	low	high

[1] LR: Limited Resource, P: Pollution, LT: Long term destruction

The aim is also to include parameters describing potential long-term effects on the soil. So far, only the risk of deep soil compaction has been operationalized. Soil fertility in a more biological sense will have to await greater consensus among soil scientists concerning the right measurements.

It should be noted that the indicators are based primarily on evaluations of farm management and production (for instance the flow of nutrients and pesticide use) whereas the actual effects on recipients like groundwater or atmosphere have been considered too expensive or insecure to measure. Soils and on-farm biodiversity might in this light be considered as something in between, since they are both part of the production system and affected by it.

Table 2. Examples of farm accounts, 1995-96.

Farm No.		1	2	3	min.-max.**
Total cropped area, ha		55	160	38	38-160
Milk delivered, t		577	906	0	306-906
Pigs delivered, t		0	0	102	102-384
Livestock units per ha		2.1	1.2	3.1	0.6-2.9
1000 MJ, total		2082	1887	5345	5345-9039
MJ per kg milk		3.3	2.3		2.1-4.0
MJ per kg pig				1109	844-1705
N-surplus, kg per ha		193	129	304	67-304
P-surplus, kg per ha		3	5	31	1-31
N-efficiency*	milk	26	23		15-34
	pork			41	28-47
P-efficiency	milk	83	57		19-83
	pork			38	27-68
Cu-surplus, kg per ha				0.2	0.2-1.0
Pesticides, AST 1.1		0.0	0.5	0.0-3.0	
% untreated area		24	100	17	0-100
% weed in grain 0		18	2	0-22	
% small biotopes		2.4	3.6	8.0	0-19

*) N-output (animalia)/N-input - N-output (vegetabilia)). **) 15 dairy and 4 pig farms.

Moreover, in agreement with Burkhardt (1989) and Thompson (1997) we do not claim that these indicators are sufficient to judge whether an agricultural system is sustainable or not. Indicators are meant as some researchers' suggestions for the operationalization of a farm's potential impact on someone's interests, now or in the future. As shown above these indicators have been chosen carefully in order to describe critical effects of the farm that have not traditionally been included in farm accounts (i.e. externalities). Many of these indicators describe effects on the surroundings that are not necessarily important for the sustainability of the farm itself (for instance N-surplus and loss) while others deal directly with effects on the farm's own production basis (i.e. soil structure). Thus, the indicators describe the current farming practices' impact on selected aspects of sustainability at different levels (farm, region, country). But since they focus on the negative impacts on these sustainability issues they rather describe the non-sustainability. De Wit et al. (1995) have suggested a similar approach, i.e. defining criteria from explicit issues of unsustainability. They also stress the importance of using criteria suitable for multicriteria analysis but on a more aggregated level.

Referring to the previous section about interpretation of sustainable agriculture, indicators shown in table 1 build on the idea behind "resource sufficiency". However, because of the co-operation with private existing farms, the concept fully respects the idea behind "functional integrity" in terms of reproduction of crucial elements in the system (Thompson, 1997). The indicators are used as a part of an ethical learning process (see self-reflection arrow in Figure 1) (Jensen & Sørensen, 1997). The working together with farm families in the development of an ethical account, facilitates studies of the management system (functional aspects), its values and how it develops in relation to elements in figure 1 (morphogenetical aspects) (Halberg, 1996; Noe, 1997).

Creating knowledge about alternatives - environmentally friendly and productive livestock farms systems

As mentioned earlier, pollution with nitrogen and the high use of pesticides are considered major environmental problems in connection with Danish agriculture. The high use of pesticides is also connected to livestock farming, since crop production is considered as an important and integrated part of most Danish livestock farms. One way to look at these problems is to look at the trade-off between e.g.. input of nitrogen and level of production. This can be done in a classic agricultural experiment. The problem, however, is that a livestock farm is very complex and there is a huge number of combinations of input factors. It is therefore very resource demanding and time consuming to create knowledge solely through experiments within existing agricultural systems.

A short cut to obtain reliable and acceptable knowledge about alternatives is to take the production process-view for the study of biological, technical and economical aspects in commercial farms. In Denmark this has been done from 1989-1993 in 20 conventional and 14 organic dairy production systems. The modelling of milk production (Kristensen & Kristensen, 1997), crop yields (Halberg & Kristensen, 1996), N-turnover (Halberg et al., 1995) and energy efficiency (Halberg et al., 1994) has given information of possible effects of extensification on these issues.

The above mentioned method is very suitable as long as there is sufficient knowledge about relevant alternatives within or close to the given agricultural systems. The problem, however, is that in some systems there are only few alternatives and therefore a lack of knowledge about more radical alternatives. In particular, there is a great lack of knowledge concerning livestock and cropping systems with no use of pesticides.

In organic farming, synthetic fertiliser and pesticides are not used. A crop rotation including perennial and N-fixing crops, together with the use of fertiliser of organic origin is regarded as the fundament for an environmentally friendly and productive farming system. Organic farming therefore offers another framework for obtaining knowledge and making research than conventional farming systems do. This in combination with the increased general interest in organically produced food has resulted in a major research effort within organic production systems in Denmark for the purpose of producing knowledge about sustainable agricultural systems.

The latest initiative is the formation of a Research Centre for Research in Organic Farming including a new research station which started in 1996. The objective of this centre is to make research with a starting point in the organic concept and agricultural problems for the benefit of developing sustainable agriculture in Denmark. The purpose is to co-ordinate the organic research activities on the basis of the existing research groups in Denmark.

For some years, a growing collaboration between systems oriented researchers working with commercial farmers and discipline oriented scientists working with controlled experiments has inspired to seek greater co-ordination of research tasks. Thus, for example, nutrient turnover is studied on a number of private farms and more detailed registrations on selected farms and research stations. This type of collaboration stimulated the idea of an attempt to co-ordinate a whole new research programme where experiments on research stations and registrations on private farms are combined.

This idea has influenced two major research programmes, which are conducted as the fundament for the Research Centre for Organic Farming. At the moment, approx. 100 scientists from 14 different institutes are participating in the centre (Kristensen, 1996a, 1996b). Figure 2 shows the headlines for the projects in the two programmes, which are conducted from 1996-1999. It appears that the research programmes cover many different levels in the agricultural systems, for instance from the individual animal (I.5 and I.6) and properties of soil (I.3) to consequences for the society as a whole (I.8).

The basic idea has been to put together the research group so that all relevant disciplines and research methods were covered. The research effort has been co-ordinated with respect to the existing expertise and geography but in a way that leads to high stimulation and reflection in the different research groups. This is considered important in order to make more innovative research and to encourage that the scientists' interpretation of sustainable agriculture becomes as explicit as possible. Finally, introducing systems thinking as a core of the research programme draws the attention to the idea that researching in organic farming and sustainability issues is not only a question of getting more knowledge of the structural/ontological aspects which are normally in focus in reductionistic agricultural research. The research programme must include the functional and morphogenetic aspects of the production as well as the management system in order to give suitable and coherent information about the possible role of organic farming in relation to sustainability issues.

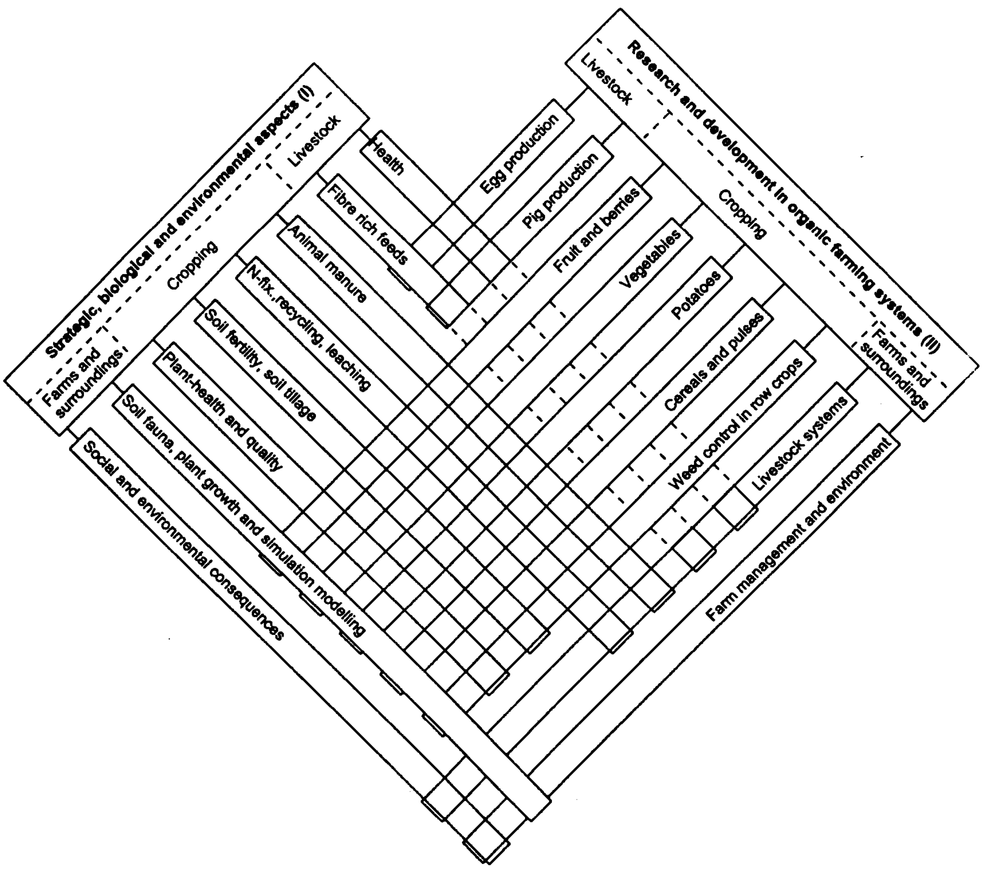

Figure 2. Research relationships within and between Programmes I and II (figures in brackets shows the individual projects. (Kristensen 1996a, 1996b).

References

Bawden, R.J., R.D. Cacadam, R.J. Packham & I. Valentine, 1984. Systems thinking and practices in the education of agriculturalists. Agri. Syst. 13, 205-225.

Beus, C.E. & R.E. Dunlap, 1990. Conventional versus Alternative Agriculture: The Paradigmatic Roots of the Debate. Rural Sociology 55(4). 590-616.

Bruntland Report, 1987. World Commission on Environment and Development. Oxf. Univ. Press.

Burkhardt, J., 1989. The morality behind sustainability. J. of Agric. Ethics. 2, 113-128.

Buttel, F.H., 1993. The sociology of agricultural sustainability: some observations on the future of sustainable agriculture. Agriculture, Ecosystems and Environment, 46, 175-186.

Douglass, G.K., 1984. The meanings of agricultural sustainability. In: Agricultural sustainability in changing world order. Douglass, C.D. (ed.), 1-29.

Dunlap, R.E., C.E. Beus, R.E. Howell & J.W. Waud, 1992. What Is Sustainable Agriculture? An Empirical Examination of Faculty and Farmer Definitions. Journal of Sustainable Agriculture 3(1), 5-39.

Foerster, H. von, 1992. Ethics and Second-Order Cybernetics. Cybernetics & Human Knowing 1(1), 9-19.

Gibon, A., R. Rubino, A.R. Sibbald, J.T. Sørensen, J.C. Flamant, Ph. Lhoste & R. Revilla, 1996. Current A review of current approaches to Livestock Farming Systems in Europe: Towards a Common Understanding. EAAP Publication No. 79, 7-19.

Halberg, N., 1996. Indicators of resource use and environmental impact to be used in an ethical account for a livestock farm. English summary. Ph.D. thesis, Den Kgl. Veterinær- og Landbohøjskole og Statens Husdyrbrugsforsøg.

Halberg, N., E.S. Kristensen & K. Refsgaard, 1994. Energy use in crop production on Danish mixed farms. Systems modelling of data from farm studies. Int. Symp. on Systems-Oriented-Research in Agric. and Rural Development. Montpellier, France, 12 pp.

Halberg, N., E.S. Kristensen & I.S. Kristensen, 1995. Nitrogen Turnover on Organic and Conventional Mixed Farms. Journal of Agricultural and Environmental Ethics, 8(1), 30-51.

Halberg, N. & I.S. Kristensen, 1996. Expected crop yield loss when converting to organic dairy farming in Denmark. Biological Agriculture and Horticulture 14, 25-41.

Jensen, K.K. & J.T. Sørensen, 1997. The idea of an ethical account for livestock farms (submitted).

Kristensen, E.S., 1996a. Strategic and basic research into organic farming systems with particular emphasis on biological and environmental aspects. Application for financial support by the Danish environmental Research Programme, 241 pp.

Kristensen, E.S., 1996b. Applied research and development in organic farming. Application for financial support by the Danish environmental Research Programme, 231 pp.

Kristensen, T. & E.S. Kristensen, 1997. Analysis and simulation modelling of the production in Danish organic and conventional dairy herds. Livest. Prod. Sci. (in press).

Le Guen, R & C. Ruault, 1994. La double appartenance professionnelle des agriculteurs biologiques. In : Pairs et experts dans l'agriculture. Darre, J.P. (ed.), Technologies, Idéologies Pratiques (12), 49-87.

Le Moigne, 1977. La Théorie du systeme général. 2. Udg. 1984. Presses Universitaires de France, 310 pp.

MAF 1991. Bæredygtigt landbrug. En teknisk redegørelse. Landbrugsministeriet. 366 pp.

MAF 1995. Aktionsplan for fremme af den økologiske fødevareproduktion i Danmark. Landbrugs- og Fiskeriministeriet, 414 pp

Mayrhofer. P. & P. Schwaberda, 1991. Die Bauern, die Natur und das Geld. Modell Ökopunkte Landwirtschaft. Verein sur Förderung der Landentwichlung und Intakter Lebensräume, Baden, Østrig, 117 pp.

Michelsen, J., 1994. Introducing EU Regulations on Agriculture and Environment - A Change of Agricultural Discourse? Paper prepared for: A Conference on Understanding, Designing and Managing Complex Regulatory Systems: Governing Our Environment, Copenhagen, Denmark, November 17th-18th, 28 pp.

Noe, E., 1997. Values and farming practices among Danish dairy farmers (in prep.).

Ploeg, J.D. van der, 1990. Labor, Markets and Agricultural Production. Westview Special Studies in Agriculture Science and Policy. Westview Press. Boulder, San Francisco & Oxford.

Ploeg, J.C. van der, 1996. Bottom-up pressures on intensive livestock systems. EAAP Publication No. 79, 37-49.

Ruttan, 1994. Constraints of the design of sustainable systems of agricultural production. Ecological Economics 10, 209-219.

Scholl, D. & J.E. Holt, 1990. Cultural change in agricultural research organisations – An urgent need. Agricultural Systems 32, 159-173.

Sørensen, J.T. & E.S. Kristensen, 1992. Systemic Modelling: A Research Methodology in Livestock Farming. In: Global Appraisal of Livestock Farming Systems and Study on Their Organisational Levels: Concepts, Methodology and Results. Gibon, A. & G. Mather (eds.). Proceedings CEC-seminar EUR 14479, 45-57.

Sørensen, J.T. & P. Sandøe, 1994. Etiske regnskaber for husdyrbrug. Intern Rapport fra Statens Husdyrbrugsforsøg, nr. 32, p. 77.

Thompson, P.B., 1992. The Varieties of Sustainability. Agric. and Human Values (9), 11-19.

Thompson, P.B., 1997. The varieties of sustainability in livestock farming. In: Livestock farming systems – More than food production. (ed. Sørensen, J.T.) Proc. of the Fourth International Symposium on livestock farming systems. EAAP Publ. No. 89, 5-15.

Thyssen. O., 1992. Ethics as Second Order Morality. Cybernetics & Human Knowing 1(1), 31-47.

Wit, J. de, J.K. Oldenbroek, H. van Kaulen & D. Zuat, 1995. Criteria for sustainable livestock production: A proposal for implementation. Agric. Ecosystems & Environment 53, 219-229.

Zijpp, A.J., 1993. Science and sustainability in animal production systems in the developed world. W.A.C.P. Edmonton, Canada. Vol. f1, 33-40.