‘DIERLIJKE PRODUCTIESYSTEMEN: OVER INTEGRATIE EN DIVERSITEIT’

‘ANIMAL PRODUCTION SYSTEMS: ON INTEGRATION AND DIVERSITY’

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Animal production systems: on integration and diversity

Mister Rector Magnificus, members of the Executive Board, ladies and gentlemen,

The year 2001 will be remembered in Dutch animal agriculture as a catastrophic year because of the foot and mouth disease outbreak. At the same time this crisis evoked tremendous societal interest never expressed before. Broad concern about the future of animal production has elicited many reports like 'Future for animal agriculture' by the think tank Wijffels, 'Of greener soils' by the foundation Nature and the Environment, 'Animal production in the year 2030' by the Society for the Protection of Animals, 'Future for animal production in the society and the market' by the Farmers Union, on the future of animal agriculture by the Advisory Board for the Rural Areas, the report 'Valuable Agriculture' of Wageningen UR, 'Towards a sustainable and vital agricultural sector' of the CDA. These reports represent diverse stakeholders. Nevertheless all support sustainable animal agriculture and expect simultaneously large adaptations in animal production systems in the Netherlands and worldwide. Globally we are still facing hunger and poverty. Overcoming this problem will not happen in the short term. The future health of the environment and the survival of ecosystems important for agriculture contribute to solving this problem of hunger and poverty.

Environment and ecology

The excess of manure has been the first major confrontation with the environment in Dutch agriculture. Long before Dr. Rachel Carson (1962) alarmed the world with her book 'Silent spring' about the use of pesticides, their effects in the food web and her concern about the survival of ecosystems. This confrontation combined with emerging ecological issues has led to the "ecological era" in animal production. In Table 1 a number of components of the environment and the ecosystem are presented with their causes and potential solutions.

Table 1 also shows that use of natural resources can lead to local and to global effects. Humans are influencing the natural and agro-ecosystems all over the world. Genuine nature does not exist any longer. Some solutions like mineral cycling and limiting transport because of energy would lead to regional food production. More land is needed for water storage, green energy, C-sequestration, nature conservation and agricultural nature management, and for organic farming. Other solutions like clean production methods in poultry and pig production are attractive for our environment. However in the long term energy cost of transport and the effects of production of feed elsewhere in the world will require change.

Table 1. Environment and ecosystem: problems and solutions

<u>issues</u>	<u>causes</u>	<u>problems</u>	<u>where</u>	<u>solutions</u>
Nutrients N, P, K				
too much	manure, feed, fertilizer	water, soil, air	farm to watershed	mineral cycles
too little	poverty	soil		mineral cycles and P en N in feed
Heavy metals	manure	soil, animal		remove from feed
Fossil Energy	increasing use	climate	world	green energy, economize, C-sequestration
Water	removal and drain	drying up	watershed	storage and economize
Biodiversity	complex	loss genetic resources	world	nature conservation, restoration
Landscape	complex	loss eco-services	region	agricultural nature conservation
Pesticides, insecticides, herbicides	ease	resistance food webs	world	IPM biological control
Antibiotics	veterinairy, feed	resistance	world	restrict to human use

Sustainable development

The concept of sustainability was first presented in the report ‘Our common future’ by the Brundtland Commission. Now we have more than 386 definitions of sustainability (Rigby and Caceres, 2001). For example: People secure sustainable development by covering the needs of the present generation without jeopardizing the capability of future generations to cover their needs.

All of us have a basic understanding of what sustainability stands for. It entails ecology, economics and socio-cultural values. This triangle is presented by Zachariasse (2000) as People, Planet and Profit. To obtain an optimisation in this triangle exchange of trade offs has to occur. Sustainability is determined by its context, the scales next to the defined production system. Sustainability is multi dimensional and its units are diverse. For political decision making it is a difficult concept.

Sustainable development is a continuing process to ensure continuity of food production. Each moment in time and location in the world the economic, ecological and socio-cultural issues are being balanced. For companies including agricultural enterprises the term societal entrepreneurship has emerged. Society expects that companies produce sustainably. Decisions about future food production take into account perceptions and values. These perceptions move between economic, ecological and societal aspects. Valuing food safety or the environment is not new. But in the past action was focussed on technical and economic goals and societal elements were not included. The goals can be understood as a justification for a better distribution of natural resources within and between generations. We have to become aware of the values in the concept of sustainability (Jacobs, 2001) and of the relations between the stakeholders in animal agriculture (Thompson and Nardone, 1999 and the report ‘Future for animal agriculture’, 2001).

We have developed a logical framework in five steps:
1.identification of the stakeholders and description of the problems of the production system;
2.determination of the economic, ecological and societal issues and the definition of goals;
3.translate the issues into quantifiable indicators for sustainability;
4.determine the contribution of the indicators to sustainable development and monitoring of the indicators;
5.exchange the results with the stakeholders, review the process and return to item one.
For the execution of the five steps different methods can be used. They vary in the application of ‘soft’ and ‘hard’ systems methodologies. There are also hybrid methods like fuzzy monitoring models. They express expectations of sustainability by connecting qualitative information with the quantifiable indicators. In his Ph. D. study Ir. Cornelissen applies this method for animal welfare and multifunctional land use. Other methods applied by APS staff will be discussed later.

Animal production and food supply worldwide

The global demand for food is growing with the increase in population. World population will grow to 7.5 billion in 2020. At the moment there are 6 billion; in 1960 there were 3 billion people. Eighteen percent of the people are suffering from hunger (800 million). Every second some one dies from undernutrition. The lack of income prevents that the whole world population could be fed now. Poverty is very complex and relates to different scales. Solutions though complex are known, but require coordinated action. See the results of the conference ‘Sustainable Food Security for All by 2020’ in september 2001 in Bonn.

During the period 1980 to 2000 an increasing demand for grains has taken place. This increased demand represents for 75% the developing countries. The term ‘livestock revolution’ has been coined (Delgado et al., 1998). The livestock revolution is based on demand in contrast with the green revolution, which was based on supply of staple foods. A higher standard of living and urbanisation in developing countries increases purchasing power. In 2020 half the people will live in cities.
With a larger demand for animal products the demand for feed grains will at least double. This increase will happen if production per ha increases by 75% and 25% more land area is utilised for crops. For the three animal production systems: grassland, mixed farming and industrial farming the changes per continent are very different. Industrial farming will increase at an enormous rate in Asia. Growth of the intensive system will occur everywhere, but in Latin America and West Asia/North Africa also grassland based systems will grow. In Asia mixed farming is expected to grow. Land availability and quality of soil determine what will happen.

More intensive animal production can cause serious environmental problems. In the study ‘Livestock and Environment’ different regions of the world are characterised for environmental impact caused by animal production. These are: regions of overgrazing in Africa and Asia, nutrient surpluses in Asia, Europe and the U.S.A., deforestation in Latin America and involution of mixed systems in Asia, Africa and Latin America. Solutions are scale dependent and different stakeholders carry responsibility. The availability of water for feed production and for livestock will regionally tip the scale.

Animal production represents a considerable added value. That added value can be expressed in economic, ecological, social and food value terms. The value of livestock can also be weighted at household level, the research interest of Drs. Udo and Moll. Livestock are usually integrated in the mixed farming system in developing countries. Livestock does not (only) represent income by sale of products at the market. Livestock are important for home consumption, for manure and traction for production of food grains and vegetables. Livestock represents a capital and financing function. Banks and insurance companies may not function properly, may not be trusted or inflation is very high. Ownership of livestock is an insurance for unexpected payments in the future for disease, housing and family ceremonies. The financing function is realised when for example school fees are paid by selling a sheep or goat. If animals can not be sold money has to be borrowed from informal lenders at high interest rates.

Research in Nigeria has shown that the value of insurance and financing was four times the value of sale of goats (Bosman, 1997). Only when the insurance and finance value was added to the income from sales, the labour income was comparable to income from crops. This result explains why farming households keep goats en do not concentrate on crops. For East Java similar conclusions were made (Ifar, 1996).

Different functions of livestock can explain decision making by farmers. For example the insurance for unexpected payments means that these animals can not be sold at the biologically most advantageous time. Research in East Java indicated that diverse functions of animals are important for the evaluation of feeding strategies. If only sale of milk and meat is important, then the best quality feed should be provided and the remainder of the crop residues remains unused. If manure, traction and ownership of livestock are important, the lesser quality feeds can be utilised and more animals can be kept (Zemmelink, 1995).

The relative importance of the diverse functions of animals is influenced by changes in land use because of crop production, by economic circumstances and markets. The evolution of animal production systems can partly be understood from the relative value of functions over time. In Europe diversity of functions is increasing. In Eastern Europe this happens because of lack if income, social security and a disintegrating knowledge system, in Western Europe because of societal interest in nature and landscape, organic farming and social care.

Worldwide we will experience a large increase in productivity, simultaneously having to conserve our natural resources soil, water, air and biodiversity. The adaptation to increased and ecologically responsible productivity will have to be socially and economically acceptable. Each household will weigh the social security versus the multifunctionality of their livestock.

Animal production in the Netherlands and Europe

In the Netherlands 11.5% of our expenditures are paid for food and drink. In the United Kingdom this is 16% and an equal amount for leisure. Expenditures for food decrease and for leisure increase (Croston, 2001). This pattern illustrates the reversal of investments in public goods. After the Second World War the first need was food security, now the need is expressed as space, quiet, clean water, fresh air, nature and landscape, all services of the ecosystem. Maslow (1952) predicted this reversal with the pyramid of needs. At the bottom first needs like food and shelter have to be satisfied followed by health and immaterial needs like learning, social activities and self realisation. There are large differences in consumption patterns and individual needs. Important public discussions nowadays are about food safety, health, nature conservation and animal welfare and not about food security. Parallel to this development is the increase in keeping pets like birds, cats and dogs. The pet sector is of economic, ecological and social significance. Their welfare may not be optimal. About 10% of the agricultural land area is needed to feed our pets and horses.

The break from food security to need for space is also illustrated in the future of animal production systems. For land based dairying this perspective is good. The number of farms is decreasing, but dairy farmers are socially respected and their farm income is good. Except on the sandy soils the dairy farmers can manage the environmental restrictions (N and P surpluses and NH3 emissions). Already in 2001 30% of the participants in “Praktijkcijfers’ is capable to achieve the environmental goals of 2002 with less fertilizer and good economic results. The dairy sector is appreciated for its landscape. Nine out of ten Dutchmen like to see cows grazing. There are no problems perceived with welfare except for very high producing cows. Dairy farmers are active in agricultural nature management: Dfl 18.000 extra income

annually on 18% of the farms. Other forms of income are also possible like recreation, sale of dairy products on farm and social care.
Organic dairying is attractive because of the higher milk price (about Dfl .10 per liter) and the N surplus is reduced with 200 kg per ha compared to conventional farms. If milk is processed on farm the milk price can be Dfl .20 per liter higher (Landbouw-Economisch Bericht, 2001). The balance between supply and demand of organic milk (products) will determine the increase in organic dairying. If the milk price becomes comparable to the conventional milkprice, many farmers will stop producing organic milk. When Arla Foods in Denmark ended paying a higher price for organic milk 10% of organic dairy farmers stopped, while they were already producing 25% of the milk.

Sheep farming is usually a second farm activity. Two thirds of the sheep are kept on land based farms. The number of sheep has doubled during the last 20 years. About 20% are owned by hobby farmers. The economic situation is difficult. Sheep are important for dike management and for nature and landscape conservation. We have many exotic breeds. Transport is frequent and poses a risk for infectious diseases. There are no concerns about welfare of sheep.

Historically keeping goats was important for landless farm employees. Then they were kept as a hobby and now also as dairy animal. Goat production has a positive image regarding environment and welfare. In future the professional sector will have to pay more attention to these issues. Identification and health control will become important. Goat milk is attractive for humans allergic for cow milk. The future of the goat sector depends on export of milk products.

Horses are kept for sport and recreation. This requires a combination of business and recreation activities in the production sector. The number of horses and pony's is about 400.000; turnover has doubled in the last 10 years. An identification system is needed for health care. Frequent transport of horses is risky for disease control in all livestock sectors. Horses have a high potential for recreation and agro-tourism in rural areas. Planning of the rural areas has to take into account bridle paths, riding schools and housing. Management of nutrients will become compulsory.

Veal calves are kept on 1281 farms belonging to two vertical integrations. This highly developed sector is very advanced in Europe, also with group housing and guaranteed quality (SKV) of product and process. The weakest part of the sector is the import of calves. They have to be transported over large distances because the number of dairy cows is decreasing in the Netherlands. The veal sector has solved environmental problems by processing urine and manure.

There are 6000 pig farms in the Netherlands. The size of the farms determines profitability and causes the increase in size. Investment for the mineral management, improved housing for welfare and manure contracts to secure land based production cause higher costs. The risk of swine fever and foot and mouth disease also play a role in cost and future opportunities. Socalled agro-production parks have been designed and planned, but this requires considerable investment. Organic farmers are limited in number. High investments are needed for transition. Markets are developing, but the total capacity is still too small.

Recently reasonable pricing of organic pigs has been agreed providing a stable base for development. For nature conservation and landscape pig production is relatively unimportant except in areas with strict environmental regulations. Restructuring of the sector is ongoing aiming to relieve environmental pressures.
From 1980 poultry production has grown with 20%. After the swine fever outbreak in 1998 some pig farmers moved to poultry. The cost of manure management is increasing. Export of manure, cooperation with arable farmers and application as green energy provide solutions. In 2010 housing in battery cages is forbidden in the EU. Growth of broilers and their parent stock causes problems of welfare and health. The number of organic farmers is small. Development of organic poultry production relies on solving problems with feather picking and adapted management and the market, where free range eggs already have a large proportion of sales and French produced broilers are competitive.

Animal production is responsible for 55% of the total agricultural production. Livestock utilises 45% of the total land,of which 63% is agricultural. The ecological footprint is much larger because of the import of feedstuffs. Between 66 to 75% of production is exported , most to European destinations. For Dutch consumption 1.3 million ha is needed for meat and .6 million for milk. This is 1.5 times the land now used for animal production. For companion animals and horses an additional 10% of land is needed. For the total production at present level at least three times the land area is used. In Europe 2% of the agricultural land is used for organic farming. The number of organic farms is increasing and was 100.000 in 1998. In the Netherlands the goal is 10% of the land to be farmed organically in 2010. Dairy production has the best perspective.

Between sectors and production chains there are many interactions. Animal production has become more specialised over time, through intensification and increasing farm size. In the rural areas tourism and recreation have become economically more important. During the foot and mouth disease outbreak the risks of the international specialisation, the dependency between sectors and other rural economic activities became apparent. Regional production can decrease these risks, but research and innovation will have to support this hypothesis.

The Animal Production Systems Group

The Animal Production Systems Group explores sustainable development options for high and low input animal production systems on a worldwide scale. The group is rooted in the former Tropical Animal Production Group. In the mid 90’s it was finally decided that an integral approach was also needed in animal production. For the specialisation Tropical Animal Production this was common knowledge. Prof. Hoekstra concluded his inaugural lecture in 1963: ’Experts are needed in developing countries with sound knowledge of animal science and understanding of the economic, social and cultural context. Experts empathizing with fellow-man’. This was the unconscious beginning of sustainabilty and participation in education and research. In 1982 Prof. Bakker presented his inaugural address titled “The position of Tropical Animal Production’. He was of the opinion, that ‘Tropical Animal production contributes to education in the Animal Sciences by presenting the whole range of systems. Then students will understand the specialist types of animal husbandry in the Netherlands’. No attention was paid to the environment. Nutrition and breeding were seen as the major means to gain productivity. During those years much experience was gained with modelling and therefore a thorough understanding of systems and processes. Prof. Zwart extended the research of the group with on farm research. His expertise in tropical diseases and animal husbandry was utilised in an integrated approach to study tropical animal production systems. Prof. Van Keulen extended this approach with multiple goal linear programming both for field work in the Sahel and for research farms. Our need for information from farms in the field and research farms is rapidly increasing. With the creation of WUR in 1999 we profit from joint facilities like research farms, and access to data sets. In the following section I will present our research with examples of hard and soft system methods.

Development of methodologies for research and education in Animal Production Systems

The mission of our group contains two key words: systems and sustainability. In the systems approach the integration of the components and their interactions are studied. The current disciplines like genetics, nutrition, ethology study components of the system, apply reductionist approaches and relate less to the context of the system. Multidisciplinary studies combine knowledge of different disciplines to provide new solutions. Interdisciplinary studies start with the problem and organise a joint research methodology of diverse disciplines.
In the systems approach we have defined three steps:

1. Problem definition,definition of the boundaries, relation with other systems and ecological and socio-economic context;
2. Analysis of features, flows and processes, inputs and outputs, relationships;
3. Interpretation of the results in relation to the context, leading to a new design.

The systems approach is not a new discipline. It is a methodology to review complex problems in animal production. Disciplinary studies and the systems approach complement each other by placing the development in the discipline in the correct context. Each research question is first analysed to decide at which scale the problem exists, how the system boundaries are determined and which methodology is best suited.

Nutrient cycles in pig and poultry production in the Netherlands

In the eighties surpluses of NPK were established for both pig and poultry farms. The national nutrient flows have been determined to improve understanding of the origin of the surpluses and review diverse management strategies. A static deterministic model was used to evaluate which strategy best decreases NPK emission (De Boer et al, 1997 and De Boer et al, 2000). The pig production system is defined, but manure outputs of cattle and poultry and the absorption of crops are accounted for. The end result is expressed as NH_3 emission in Gg N and in NPK losses in kg per ha agricultural land. The effect of different strategies can be compared with the NMP goals of legislation. For pig production NH_3 emission is the largest problem. Regionally these emissions can be higher, because the model is based on the Netherlands as a whole. With the strategies of the early nineties pig production had to be restricted from 24 to 62%. Eleven years later many improvements have been made through manure processing, nutrition and housing. Designs have been made for agro-production parks which optimise environment, welfare and infrastructure. Application of this model over time

will show the effects of new regulations and technology. Application on a regional scale and for organic farming is also useful.
For poultry production layers and broilers have been combined. Here the NH3 emission is the largest problem. New calculations are neede as the poultry population has increased, new technology is introduced for feed, manure and housing.
Regional application of the model in the provinces with restructuring programmes could be useful for planning purposes.

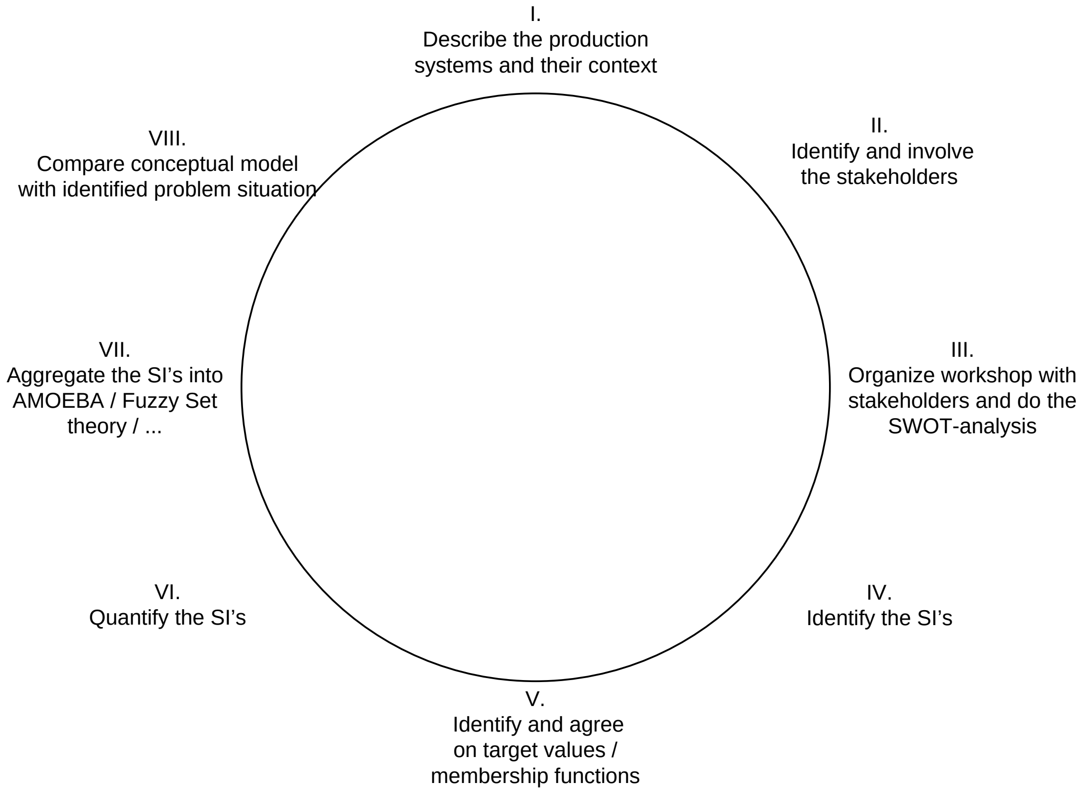
Besides the model for nutrient cycling a toolbox is available to monitor the environment. These methods vary from the ecological footprint, Embodied Energy, conventional and Emergy analysis to Life Cycle Analysis (LCA) for greenhouse gases, acidification, eutrification and land use. Application by Dr. De Boer, Ir. Smit and students is ongoing for different production systems and regions.

Animal friendly housing and sustainability

Battery cages for poultry will be forbidden and sows have to be housed in groups as a result of political decisions. Politicians appear to have ignored the sustainability of the whole production system. To compare three housing systems for layers the next steps were made: which issues are important for sustainable development, which indicators can be used for characterisation and what do they contribute to sustainabilty. Based on literature and interviews with experts Dr. de Boer and Ir. Cornelissen decided which indicators are important, measurable, distinguishable and informative and what is the optimal level. Eight indicators remained in the analysis and were unweighted. The battery cage scores well except for welfare. The indicator for welfare, the Hen Welfare Index, has to be improved with feather picking before the index is suitable for all systems of housing. In an other study the AMOEBA presentation is used following the same methodology.
The analysis is dependent on the views of experts. And therefore may not always represent a correct and complete view of the system. These methods enable us to combine information of different disciplines (ecological, economic and social), even at different region and time scales. The effects of development of new production systems can be evaluated for the household and for the region and by collecting data from field validation is also possible (Pastore and Giampietro, 1998).

Ir. Mollenhorst is comparing five housing systems for layers in a NWO funded study. They are battery cage, aviary, free range, free range with turn out and organic poultry. The basis of the comparisons and the methodology is shown in the scheme on the next page.

The final model will be the result of integrating aspects with a quantifiable basis. The aspects have been collected through interviews with stakeholders, SWOT (strengths, weaknesses, opportunities, threats), consulting experts and quantitative analysis. The model will be validated by scoring on farms in the field. It is hoped that the model can be used for evaluation of new systems by poultry farmers, IMAG, PV or ID Lelystad. The model will have to be adapted over time to include societal changes.



We frequently utilise the SWOT to make a selection of research problems in complex situations and to analyse future perspectives of production systems. For example the research on iguana systems in Latin America by Dr.Eilers was based on a model developed from SWOT. A sustainable iguana system has to provide income for the farmer and conserve the species.

System behaviour in Kenya

In Kenya small scale dairy farming is responsible for 70% of production. Dairy cows are an integral component of the mixed farm. The development of dairying is the result of favourable ecological conditions in the highlands, the distribution of colonial farm land, the changes in land ownership and the value of milk in the diet of Kenyans. The process of intensification is caused by population growth, division of land by inheritance, donor aid and growth of urban demand.
Research on dynamics of small scale dairying in Kenya by Bebe Omedo has identified three production systems in the highlands: zero grazing, grazing and a combination. In the zero grazing system the farm area and the number of cows is smaller, the number per ha is larger and the milk production higher. The more intensive systems have more Ayrshire and Friesian cows because of their higher expected yield. On the farms with grazing Guernsey's, Jersey's and East African Zebu are kept. These farmers value resistance to suboptimal conditions and potential for traction. In the zero grazing system fertility is lower, mortality higher and longevity is shorter. These farmers have insufficient animals for replacement. The problem is lack of feed according to the farmers. Economic results are also the worst on the intensive farms. Intensification will continue through land pressure. The dairy system becomes less sustainable and involution takes place. In the long term livestock may disappear causing negative effects on soil fertility.

In another joint study with ILRI Zemmelink (1999) concluded the same for Kiambu district. The available feed was insufficient for the livestock population. Many families have only one cow and there is evidence that slowly cattle are disappearing from mixed farms. Dr. Zemmelink also noted problems with manure management resulting in mineral losses despite the larger inputs of concentrates. Both aspects characterise involution of the mixed sytem.

Involution of mixed systems occurred earlier in Bangladesh. Animal production in grazing regions produced better technical results and higher economic returns in comparison with areas where livestock was dependent on crop residues (Udo et al, 1992). The loss of grazing is inevitable because the land is needed for staple crops for the growing population. Only economic development can offset this process with a higher demand for milk and import of concentrates from elsewhere. This happened in Bangladesh in the last ten years.

System development of poultry in the tropics

About 75% of all households in developing countries have village poultry, mainly chickens and ducks. These birds look after themselves, sometimes housed at night in simple to very elaborate structures. Donor organisations have become more interested in village poultry because of their potential for development. Women and children are responsible for poultry and represent the poorest people of the village. There are numerous opportunities for improvement, but the farm households do not invest because of high risk, extra work and lack of financial returns. The 'Bangladesh Poultry Model' combines technical improvements with a micro credit system. Now two million women are involved in production, inputs and services for poultry. Two thirds of the women have started to increase their assets with more livestock using new loan opportunities and investment. This process is like a ladder where over time the size of livestock increases and the type of land use arrangement, all resulting in less poverty (Dolberg, 2001).

A relatively large proportion of our international students arrives in Wageningen to do research in poultry. Present information is descriptive and anecdotal. Interventions in these complex systems are often not evaluated or only for components. The results are disappointing and the project is ended. Dr. Udo and his students have build a simulation model based on field data of diverse countries. This is a unique approach for village poultry. For ruminants such a model is available, PCHerd and used with success. Interventions that can be evaluated are NCD vaccination, permanent housing, extra feeding, crossing with modern hybrids and management techniques. After a first screening the most promising interventions can be tested in the village. Using the model also indicates which field data are needed to understand the products of the model. Participative techniques are necessary to gain practical insight in the application of interventions with potential according to the model analysis. We have formulated a project for integration and application of hard and soft systems methodologies for village poultry. There is a large demand for the simulation model as the 'Bangladesh Poultry Model' is being introduced in many countries.

Organic livestock farming

Our mission includes organic livestock farming. We wish to contribute to the development of organic farming systems with research, education and debate in the Animal Science department. This knowledge can also contribute to improved sustainability of conventional farms. The goals of organic farming are summarised as follows: sustainable, natural, environmentally friendly and healthy (Organic Farming in Wageningen University and Research Centre, 2000). These goals have become absorbed in the regulations for organic agriculture. However the basis of organic farming is the maintenance of nutrient cycles and balancing health and welfare of the system and for the functioning of man and animals in the system. The consequence is that fertilizers are not allowed, concentrates have to be of organic origin and crop protection chemicals and antibiotics are not used. The management has to employ biological and ecological knowledge to achieve a economic and socially acceptable result.

Our research has been focussed on comparisons of organic and conventional farms for environmental aspects like green house gases, acidification and eutrification, land use, health and welfare. The LCA has been used to study the environmental impact. The LCA estimates environmental impact for the product from raw material to consumption. For the comparisons of dairy farming systems all inputs are traced for their composition. The result is expressed per liter fat and protein corrected milk (FPCM). For comparisons of welfare a few methods are available, but for health there are no suitable criteria. In cooperation with ID Lelystad, PV, Veterinary Faculty and our colleagues in the Animal Science Department we hope to address this problem.

A model simulating average conventional and organic dairy farms was the basis for the ecological results presented in Table 2. The farms are about 30 ha, have productions of 12600 l FPCM and 9340 l, and 1.6 and 1.4 cow per ha respectively. Then the calculations were done for the three ecological parameters.

Table 2. Ecological parameters for sustainability of dairy farms

	Traditional	Organic
Greenhouse gas emissions (g.L^{-1} FPCM)		
CO_2	350	243
CH_4	29	33
N_2O	0.6	0.1
CO_2-equivalents	1129	974
Acidification emissions (g.L^{-1} FPCM)		
SO_2	1.0	1.1
NO_x	12	7
HCl	0	0
NH_3	1.3	0.9
SO_2-equivalents[2]	13.0	7.8
Land-use (m^2. L^{-1} FPCM)		
For roughage	0.91	1.12
For concentrates	0.20	0.51

From other research we know that the N and P surpluses on organic farms are minimal compared to 250 to 300 kg N per ha for conventional farms (Landbouw-Economisch Bericht, 2001). Organic farms score better for N and P surpluses, for green house gases and

acidification. They produce more methane gas through higher roughage intake and they need about 50% more land to produce feed. These results are attractive for the environment and ecosystem and they also show good financial results. The emissions can be improved by lower use of energy. Organic farms have opportunities for agricultural nature conservation, water quality management and recreation. The most critical and crucial issue is the need for land even though the land maintains its potential to be productive for future generations.
We are now preparing a project proposal for similar research with field data of farms to gain insight in the variation of ecological, welfare and health indicators. We hope to learn of bottlenecks and provide solutions (often already practiced).
Recently a qualitative evaluation of the knowledge system for organic dairy farmers showed that new and experienced farmers have different extension relationships and different needs for research. The new group is externally motivated and is directed by the regulations for organic farming. The experienced group is interested in a balanced ecological management and has internal motives. The composition of the groups changes over time. The differences in extension needs are related to history, culture, values and experience. Dr. Oosting will include these social elements in future research for sustainability. Differences between groups of farms are caused by diverse conceptions of management.

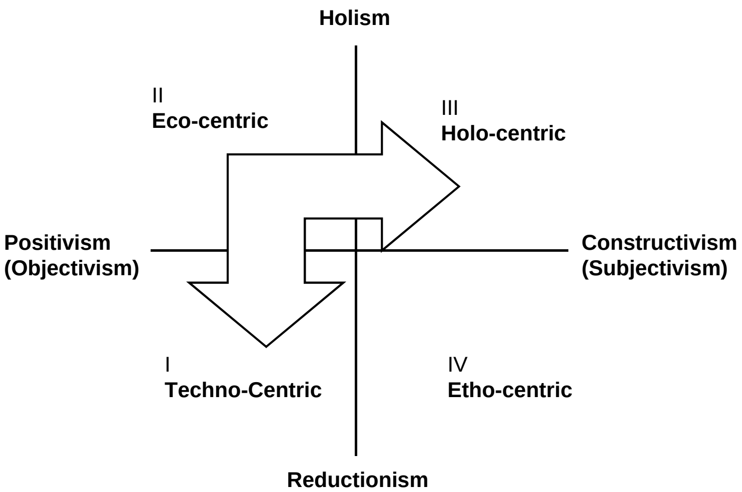
Integration of arable farming and broiler production

The Netherlands is a big grass seed producer. As the application of TCA, a herbicide, was prohibited, the harvest of grass seed is hampered by wheat. Together with PAV on farm experiments were organised to test the capacity of free range broilers for cleaning the land from wheat grains. The broilers were not very effective in cleaning, but the system proved to be financially attractive for arable farmers. A dynamic model with STELLA has been created. In collaboration with stakeholders Dr. Kwakkel and students are reviewing the potentials like welfare and health, predation, extra income, exchange of wheat, manure, labour and knowledge between poultry and arable farmers, variation in the landscape and a high added value. The potentials of this system might be even more attractive for organic farmers.

Future developments

From the previous section you will have understood, that combinations of hard and soft systems methods are more frequently applied. This integration has two causes. First the context of the system plays a more prominent role. The change from food security to other diverse values in agriculture implies another role for farming. The second reason is that our decision to contribute to sustainable development forces us to study the trade offs between economic, ecological and social aspects of a system. Our research moves from analytical research only to integration with values of people regarding aspects of the production system. Earlier Thompson and Nardone(1999) have noted the changes in conceptions about the utilisation of scarce natural resources versus functional integrity of animal production systems. In Figure 1 this change is presented (Roling, 2000).

Figure 1. Paradigms in four quadrants (after Bawden , Roling, 2000)



In Figure 1 two axes are presented dividing the space in four areas. In the techno-centric tradition research is carried out with reductionist and objectivist conceptions. In the second quadrant a new combination of disciplines (life and social sciences) leads to the eco-centric approach. Examples are integrated pest and nutrient management. Often research is done on farm and with farmers. In the holo-centric quadrant interactions between people and problems are most important with interdisciplinary and systems based research. The fourth quadrant, the etho-centric area, completes the field. Norms and values will determine the approaches and the trade offs. The four quadrants are not independent, but complement each other.

Our expertise covers only part of the methodologies for systems research (see Bawden, 1997). Our focus on environment, welfare and development of organic and tropical livestock farming is sufficiently diverse to create opportunities for new system methodology. For example a project for reflection of the foot and mouth disease crisis contains interdisciplinary and interactive methods. We hope that this project will assist in the development of new scenarios to control the disease and to support a societal approach involving all stakeholders.

Cooperation and education

For future research and education our group cooperates with many groups in the Animal Science Department, in Wageningen University, with DLO institutes, PV, the Louis Bolk instutute and the CGIAR institutes and many others here and abroad. For our group this cooperation is a basic need. From the beginning of the Animal Production Systems group in 1994 the number of students specialising in systems has grown from 8 (17% of Animal Science students) to 21 in 2000 (33%). In addition there are the international M.Sc. students and about 10 Ph.D.'s. Courses are presented in English from the second year. A considerable number of students are supervised jointly with colleagues from Animal Science groups and the DLO institutes, with socio-economists, plant scientists and with colleagues abroad.

Words of gratitude

Many colleagues, friends and family have contributed to my career and therefore to the position and responsibility I now carry. I have appreciated your support very much and hope that the many positive interactions at work and personal level will continue. We have a lot of work ahead training large numbers of students and will continue to access your support in future. We need you to strenghten our systems approaches, to learn from new production systems and to apply the integration of soft and hard systems for more sustainable animal production systems.