Learning to be sustainable. Does the Dutch agrarian knowledge market fail?

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Abstract

The availability of adequate knowledge is an important prerequisite for the achievement of sustainable forms of agriculture. It will be shown that the nature of the knowledge necessary for this differs from that which forms the basis for conventional agricultural practices. The generation of such knowledge requires other forms of research and extension than those that are currently widespread. It is now necessary, more than ever before, to direct efforts towards the organisation and support of joint learning processes aimed at the development of new technologies (and accompanying social-organisational arrangements) at local level. While the first part of this article outlines some basic methodological elements that may be relevant in this respect, the second part addresses the question of whether changes occurring in the Dutch agricultural knowledge network are helpful in bringing about the required forms of experiential learning and interactive technology development at local level. It is argued that market-oriented knowledge policies in agriculture (e.g. in the form of privatisation of research and extension institutions and 'output-financing') pose a number of threats to this. It is suggested that the idea of a 'knowledge market' is logically connected to outdated forms of linear thinking with regard to the source of innovation processes. In relation to this, a number of aspects causing friction are identified in the co-operation between farmers, extensionists and researchers. With reference to insights from (institutional) economics, it is concluded that other institutional arrangements than markets are probably more suitable when the aim is to support experiential learning and interactive design towards sustainable agriculture. In such processes, applied knowledge and information cannot be treated as marketable 'end-products', but are better regarded as 'building-blocks' that need to be re-arranged and re-shaped through numerous creative 'transactions' and exchanges. If all of these transactions have to be paid for, innovation is unlikely to emerge.
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Introduction

The question 'how do we go about making agriculture more sustainable?' includes not only technical issues, but also a number of social-organisational dimensions. Examples of pertinent questions would be: 'Within which social parameters would farmers be willing or able to make their enterprise more sustainable?'; 'What social bottlenecks exist as regards these parameters?'; 'How can more stimulating conditions be created?' It is impossible to answer these questions exhaustively within the limits of this article. We shall therefore concentrate on only one of the parameters concerned, namely the fact that making agriculture more sustainable presupposes the availability, exchange and application of adequate knowledge and technology.

The nature of the required knowledge[1]

It is important to establish the precise nature of the knowledge needed in order to promote more sustainable forms of agriculture. If the area of concentration is limited to 'agro-technical' knowledge, then three issues present themselves. Although there may be disagreement over the precise meaning of the term 'sustainable', it would seem self-evident that such types of agriculture – whatever the exact definition – require farmers to manage and bring together

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ecological processes and cycles in a very careful way. In crop-protection, for example, it is no longer sufficient merely to apply a number of preventative sprayings according to a standard procedure. Instead of this the issue which arises is the maintaining of a balance between pests and their natural predators and the maintenance of ecosystems in which the latter exist. The managing of this kind of 'balance' requires a solid insight into complex ecological processes and interconnections. A second feature that seems to be important is that sustainable agrarian practices will probably need to be more varied than conventional practices. In the crop rotations of biological farmers, for example, a greater number of crops have their place, and a certain amount of integration with stock grazing would seem to be an obvious step. This 'de-specialisation' means that a broad spectrum of knowledge is necessary. Lastly, it is evident that ecological processes and situations are by nature localised since important differences can exist within individual regions or even individual fields. Insights with specific reference to the local situation are therefore essential. In short, the nature of the requisite knowledge could be described as complex, diverse and local.

Shaping the necessary learning and technology development processes

The long-held idea that knowledge is generated by science, diffused through education and extension, and put into practice by farmers, already reflected inadequately the factual dynamics of knowledge development and application in conventional forms of agriculture (Röling, 1992; Van der Ploeg, 1987). A great deal of knowledge and technology is developed or reinvented by farmers (Richards, 1985), many extension agents mainly transfer knowledge from one farmer to another (Leeuwis, 1993) and many scientists build their research on practical experiences (Vijverberg, 1997). This 'linear thinking' -which has also been criticised in the context of industrial innovation (Kline and Rosenberg, 1986; Rip, 1995)- is even more out of place in the context of sustainable agriculture, because here a pool of partial insights has to be interpreted, integrated and refined at local level, and during this process new knowledge and technology is likely to be created. At an enterprise level this calls for a continual succession of action, observation, reflection, adaptation and experimentation; in short, experiential learning (Kolb, 1984). Next, I will focus on the question of how this experiential learning, which takes place in the context of more or less 'everyday' decision-making and problem-solving, can be supported by a third party (extension agents, for example). Subsequently, the focus will shift towards the organisation of more deliberate knowledge and technology development trajectories.

Supporting experiential learning to promote sustainable farming

As is the case with scientists, farmers are often busy carrying out small experiments and developing and evaluating 'new procedures'. Drawing conclusions (i.e. making new insights explicit) based on slight changes in one's own farm management is not easy for farmers. In an enterprise situation there are often a number of possible explanations for certain phenomena, because all kinds of 'variables' are changing and evolving at the same time. The capacity to draw valid conclusions on the basis of experiential learning can, however, be improved in a number of ways.

Learning in groups

One important way of arriving at conclusions regarding complicated problems and phenomena is by talking to people with similar experiences. It is not surprising that – in the Dutch context – a phenomenon like study groups is most developed in a sector like horticulture, where the availability of climate and fertigation (i.e. combined irrigation and fertilisation) computers causes a very complex situation to exist. Complex in the sense that – through the data-collection capabilities and the many optional settings of these computers – an enormous range of possibilities emerge for the monitoring and manipulation of the production process. Within one's own enterprise it is utterly impossible to investigate and evaluate all the possibilities. Study groups have also played an important role in learning processes in relation to biological pest control (Proost, 1994; Van de Fliert, 1993). Stimulation and the guidance of group learning can therefore make an important contribution to making agriculture more sustainable.

Organising feedback: flexible data-collection and enterprise comparison

Gathering feedback with regard to one's own

enterprise management methods (and their effectiveness) is an important learning mechanism. Feedback is important for the drawing up of a ‘learning agenda’ and for forming conclusions about important issues, and can be organised in various ways.
The regular registration of data and the calculation of ‘reference parameters’ with regard to one’s own enterprise management (in the form of e.g. accounts, a mineral balance, or some kind of ‘yardstick’) can be an important source of feedback. This kind of analysis of developments in one’s own management system is often an important stimulus for reflection, especially when the data are compared with those from other farms; farmers are often very sensitive regarding how they are performing compared with others. For the interpretation of data and reference parameters it is often crucial to look at the practices that produced these figures, so here too dialogue with others is essential. If learning processes are to be effectively supported in this way, it is important to provide for data-collection opportunities which interface with the diverse and ever-changing study interests of farmers (c.f. Leeuwis, 1993).
Besides the organisation of facilities for data-collection and enterprise comparison, simpler ways of supporting learning processes with feedback also come to mind. For example, the organisation of visits to farms showing unusual practices or results.

Supporting on-farm research
As already mentioned, on-farm experiments have a different logic to scientific experiments. Taking this logic into account (and not attempting to convert farmers into scientists), there are all kinds of possibilities for supporting farmers in their research (see also Röling and Leeuwis, 1998). Small changes in the design of farmers’ experiments can sometimes lead to a considerable increase in the accuracy of the conclusions drawn. The same goes for data-collection procedures and observation protocols. Furthermore, research capacity of agricultural enterprises can be increased by bringing about some co-ordination in the variety of experiments that different farmers conduct. In this way complementarity of experiments can be ensured, while unnecessary duplication and ‘reinventing the wheel’ can be avoided. In order to increase the scope of research it can sometimes be desirable to offer facilities that cover any risks involved in the research (e.g. crop failure or losses due to unforeseen spread of diseases from experiments). Finally, third parties can also make useful contribution to the identification of relevant problems and subjects for research by farmers (see e.g. Van Schoubroeck, 1999), and also to the exploration of interesting (and more or less orthodox) ‘treatments’ within the framework of such experiments.

The facilitation of ‘translation’ and ‘switching’
In a farming enterprise, different ‘domains of activity’ are brought into contact. Van der Ploeg (1991) speaks of areas such as ‘production’, ‘reproduction’, ‘family and community’ and ‘economic and institutional relations’. Within each domain there are a great many sub-areas and sub-tasks; for example, ‘manuring’, ‘milk production’, ‘grazing’, ‘animal health’, etcetera. Apart from such a functional type of segmentation of an agrarian enterprise there is also a hierarchical subdivision (e.g. ‘the cow’, ‘the herd’, ‘the farm’, ‘the farm and its environs’, etc.). A learning or problem-solving process usually starts at a certain level and within a certain domain. It is, however, impossible in most cases to draw valid conclusions without taking other domains and levels into consideration. This is why there is a constant ‘switching’ between different areas and levels during a learning process, which means that continual ‘translations’ have to be made of problems, practices and solutions from one domain or level to other domains and/or levels (Stolzenbach and Leeuwis, 1996). The support of such switching and translation activities can be an important contributor to learning processes. Various aids, such as brainstorming sessions, simulation models and spreadsheet techniques, can be helpful in this respect.

Making ecological processes more visible
Ecological processes and balances are often difficult to observe and/or are rather abstract. In order to increase an understanding of this kind of processes, it is important to make them visible to farmers in some way. With biological crop-protection, for example, this was achieved through the use of observation techniques such as ‘counting bugs’ and the establishment of small ‘insect zoos’ in the crop, where the behaviour of pests and predators could be studied (Van de Fliert, 1993). Elsewhere, there has been some success with efforts to give a visual

demonstration of the relationship between different forms of tillage and hydrological processes by means of a 'rain simulator' (Hamilton, 1995), With the aid of this machine a shower of rain could be mimicked on farm plots, and measurements taken of the amount of water that ran off (causing erosion) and the amount that was absorbed by the soil. With other ecological processes (regarding nutrient flows, for example) it would seem less simple as yet to develop forms of visualisation that give real insight into what is happening. No doubt computer animations and the like can play a role in this, but it remains a formidable challenge.

Computer simulation

The progress of learning processes in agriculture is sometimes restricted by the fact that only a limited amount of experimentation can be conducted at any one time (Rossing et al., 1997). Furthermore, the results of experiments at enterprise level can only be judged after one or more production cycles. Moreover, it sometimes happens that farmers abandon certain experiments because the possible risks are too great or because legal constraints do not permit these experiments. In some cases the possibility exists for conducting 'virtual' instead of 'real' experiments, with the aid of computer simulation techniques (Vereijken and Kropff, 1995; Rossing et al., 1999). Models for simulation and optimisation usually highlight only a small number of aspects of farm management, and, by definition, do so in a much-simplified manner. It is important, therefore, that the results of such 'virtual' experiments be judged on their internal and external validity by farmers in a process of switching and translation between various levels and domains of farming (see above). One condition for all this is that the simulations used are (or are made to be) transparent for the needs of such a learning process.

Knowledge and technology development through deliberate projects

In order to counter persistent problems and challenges, everyday experiential learning may not suffice, so that applied research projects will have to be established with the aim of developing new 'sustainable' production systems, practices and technologies. This raises the question of how such design paths can be shaped, and what the task distribution should be between natural scientists, social scientists, farmers and other parties concerned. I shall not try to present an extensive design methodology here (for this see Vereijken, 1997; Leeuwis, 1999), but will highlight a number of relevant insights and principles.

Interactive development of knowledge at local level

As has already been mentioned, the knowledge and technology necessary for sustainable agriculture will have to be attuned to local ecological conditions. Experiences with precision agriculture show, for example, that it is exactly that essential local knowledge which is lacking (Stafford in Reuvekamp, 1997). The whole battery of high-tech aids for the visualisation of specific differences in environmental conditions (remote sensing, yield charting, etc.), and also the advanced array of computerised machinery which should make it possible to intervene in a precise manner (variable manuring, selective spraying, etc.) cannot be utilised in a meaningful way if there is a lack of insight into the interactions that are relevant at local level[2].
For this reason alone it is crucial to work in conjunction with farmers (who are best acquainted with local conditions) when developing knowledge and technology. Now, more than ever before, research will have to be conducted –at least partly- outside the conventional scientific research facilities (see also Van Schoubroeck and Leeuwis, 1999).
There are also other reasons for extensive co-operation between farmers and researchers.
Not only must newly developed practices and technology be effective technically under local conditions but also in social the sense. This means that they must be practicable and fit within the framework of a system of carefully co-ordinated farm management (Van der Ploeg, 1991) as well as wider social-organisational (i.e. institutional, cultural, legal, political, economic, etc.) arrangements and conditions (Van Schoubroeck and Leeuwis, 1999). In the identification of possible technical solutions it is therefore important to consider farmers' views regarding their compatibility with prevailing management demands and wider social-organisational conditions, respectively the opportunities they see to change the latter in line with such technological innovations. Finally, it is of great importance for the responsible application of new sustainable practices and technologies that farmers completely grasp the ecological connections and processes within and

by which changes are being made. Allowing farmers an active role in development processes contributes to the transfer of the learning experiences that underlie the newly developed practices and technologies.

The nature of the process: learning and negotiation

Co-operation with farmers in technology design has repercussions on the nature of the process. According to conventional thinking, technology development is seen as the result of a focussed and rationally organised process, which is usually phased according to established rational decision-making or problem-solving models[3]. More recently, the need has been emphasised to work through the problem-solving (and/or research) cycle more than once. One example of this is the prototyping approach (see Vereijken, 1997; Vereijken and Kropff, 1995). The development of technology is therefore being increasingly regarded as an iterative learning process. Such a conception of technology development as a 'planned learning path' falls short of the mark, however, because it does not take into account the fact that the application and development of technology takes place in the context of competing societal interests. Farmers, environmentalists, nature conservationists and rural dwellers, for example, all have different concerns and interests and hence define 'sustainable' agriculture differently. Defining certain farming practices as 'problematic' (i.e. with the aid of problem definitions and research questions) and proposing alternatives therefore, cannot be considered as politically neutral activities. In many cases – and certainly where sustainable agriculture is concerned – problem definitions, research questions, facts and solutions are a cause of social dispute and subject to debate. When there is active co-operation with farmers and/or other interested parties, one cannot avoid attracting such discussions and conflicts of interest. Thus – whether one likes it or not – such design processes become more or less like negotiation processes. A process of interactive technology development can therefore be best described as a mixture of a negotiation process and a learning process. This statement leads to the conclusion that it would perhaps be a good idea to consciously organise technology development as a learning and negotiation process (Leeuwis, 1995, 2000). This means, amongst other things, that the guidance of technological development should perhaps be based on the dynamics and phasing of negotiation processes, something that would have rather far-reaching consequences[4].

The role of applied beta and gamma scientists

Within a collective learning and negotiation path that is aimed at technology development, an inter-disciplinary team of scientists can play an important role. Not so much as 'owners' of the process but as a group of 'resource persons'. Natural scientists can, for example, contribute their own insights regarding ecological interconnections and problematic practices, answer queries which other negotiation partners might have about this area and bring in experience gleaned elsewhere with sustainable practices. Moreover, they can make an important contribution to the formulation, establishment, application and evaluation of research (on-farm, in research facilities or in 'virtual' research). Furthermore, commenting on the reasoning put forward by others regarding technical and natural processes can constitute an important contribution. Making ecological processes transparent and visible is also a task that seems eminently suited to natural scientists.

Social scientists can make an essentially similar contribution with reference to socio-economic processes. In addition to this, the analysis of the 'social logic' of agricultural practices can be of particular importance when drawing up a relevant agenda for technological research or other kinds of activities. In many cases the technology and knowledge necessary for more sustainable farming is already available, but there are all sorts of social-organisational, cultural, and/or political obstacles to their application. For example, there could be problems such as sub-optimal provisions (e.g. in the areas of inputs, information and credit), problems regarding market organisation, social risks, lack of (self)confidence, land-insecurity, inadequate community organisation, etcetera. It is therefore of paramount importance to analyse the reasons why farmers do or do not apply certain practices or technologies. On the basis of such an analysis an examination can be made of where and whether the development of new knowledge and technology is the most suitable solution, and of where other types of design strategies (institution building, legislation, collective action, marketing, etc.) might be preferable. Social scientists can thus contribute to the identification of more (and less) promising research questions and solution directions. During the preparation phase, social scientists can – on the basis of preparatory research – be very helpful to the composition of an ‘optimally heterogeneous’ negotiation team. A team of which the composition is too diverse (in terms of farming styles and/or interests, for example) has little chance of achieving productive and creative solutions and compromises, while a completely homogenous team would perhaps put forward solutions that would only be relevant to a very specific group (see Leeuwis, 1995).

Process guidance
A learning and negotiation process does not run itself. In most cases such a process would run more smoothly if it was to be guided by someone with the necessary insight and proficiency in the fields of social interaction, negotiation and communication, and who had, in addition, sufficient understanding to tap into the relevant scientific expertise. In other words, a new style ‘social agronomist’ trained in both beta and gamma sciences, who is able to facilitate innovation in technical and social-organisational domains simultaneously.

Bottlenecks regarding knowledge development and exchange within a changing knowledge network

The development and implementation of sustainable agricultural practices will make a great demand on the active involvement, creativity, inventiveness and learning abilities of farmers and horticulturists. Such a contribution by farmers and horticulturists can only be expected if they are stimulated, challenged and supported. Efforts to simply ‘force’ sustainable agriculture on them with the aid of restrictive measures seem to be too one-sided and doomed to failure[5]. Goewie and Van der Ploeg (1996) have indicated that there are too few stimuli in the areas of policy, representation of interests, research, education, market regulation and consumer behaviour. In relation to the foregoing, a particularly relevant issue is the extent to which the agricultural knowledge network is capable of contributing to experiential learning and applied technology development towards sustainable agriculture. In the Netherlands (and elsewhere) the actors and dynamics in the agrarian knowledge network have changed considerably in the last decades (see e.g. Rivera and Gustafson, 1991). Important changes include the increased spreading of market mechanisms in the knowledge network, the legal privatisation of extension and research institutions, and the merger between agricultural research institutes and the agricultural university into Wageningen University and Research Centre. Internationally, the reasons for governments to stimulate the development of agricultural knowledge and information markets are several, and partly differ from context to context (e.g. Western and Southern countries; see Umali and Schwarz, 1994; Rivera, 1991; Wilson, 1991; Le Gouis, 1991).
In the Netherlands, important influences and arguments included (see e.g. Verkaik and Dijkveld Stol, 1989):
– increased trust in economic theory and the efficiency of market forces, linked to a wish to improve the efficiency and flexibility of research and extension;
– sufficiently high incomes in commercial agriculture for farmers to pay for agricultural advice that leads to increased profit;
– agricultural overproduction and reduced public support for subsidising the agricultural sector;
– reduced electoral and economic importance of the agricultural sector;
– a wish to make agricultural research and extension more client-oriented and demand driven, and to resolve the long-standing friction – experienced by public extension agents – between policy-implementation and client-serving functions;
– a wish to ‘open up’ the knowledge network (and reduce the influence of agricultural lobbies of primary producers in setting research and extension agenda’s) in order to create more space for ‘new’ concerns such as environmental issues, natural resource management, consumer concerns and chain management;
– a wish or need to reduce government spending in view of deficits.

Although the changes resulting from market-oriented policy-measures have not yet fully crystallised, there seem to be a number of threats – besides the opportunities – to the innovative capacity of the network in terms of sustainable agriculture (see also Renkema and Leeuwis, 1998).

The linear dimension of the ‘supply and demand’ metaphor
According to market-oriented knowledge policy,

especially ‘applied’ (agrarian) knowledge can be regarded as a private property and saleable good, for which the user must, in principle, pay (see Verkaik and Dijkveld Stol). In this context, the phrase ‘supply and demand’ is used more and more frequently with reference to knowledge. The ‘demand’ side is mostly associated with users of knowledge while the suppliers are thought of as developers and transmitters of knowledge. The metaphor of supply and demand therefore carries with it the idea of a clear division of tasks between the three parties. In other words, innovation processes are essentially regarded as linear in nature. Many studies on innovation, however, have shown that in everyday practice researchers, extension agents and farmers are all occupied with the development, exchange and use of knowledge, and that it is precisely the recognition of this non-linear and non-exclusive task-sharing that can contribute greatly to the achievement of successful innovation (Engel, 1995; Röling, 1996; Leeuwis, 1995; Vijverberg, 1997). As argued above, it is especially important to treat farmers as co-developers of innovations when it comes to the promotion of sustainable agriculture. Strict adherence to the principle of supply and demand could form an obstacle to interactive design processes that would be of benefit to sustainable agriculture. This is shown, for example, by the following observations on the co-operation between applied research and extension.

Market mechanisms and the creation of parallel knowledge networks

The privatisation of the Dutch extension service, now almost completed, has caused a split between practical research and DLV, the privatised extension service, in several sectors. Apart from the creation of spatial and cultural divisions, there are tensions between these institutions over the question of who should pay whom for what, and why. Should DLV pay for the results of collectively financed research? Should applied research pay DLV for the identification of relevant questions from the field? Can the now legally independent applied researchers set up their own ‘extension branch’? Do their clients pay extension agents for the knowledge they supply or only for the transmission and translation of that knowledge? The tensions that have arisen seem to be leading to an effort by the applied researchers to compensate for the newly created lack of communication by setting up their own advisory channels, while the private extension services take initiatives in the research market. It would seem, therefore, that there are two largely separate knowledge networks coming into being that will compete on the knowledge market. Such forms of competition might act as a stimulant to innovative research, but could also lead to research duplication and a decrease in research capacity on specific issues. It therefore remains open to question whether this development contributes to the efficient support of the desired ‘ecologisation’ of agriculture.

The undermining of mutual knowledge exchange

The fact that farmers and horticulturists, more and more often, have to pay for advice and research also seems to contribute to a diminishing willingness to exchange knowledge among them. In this context, it is significant that the Association of Dutch Horticulture Study Groups (NTS) had to give up on their long-defended ideal of open mutual knowledge-exchange (Oerlemans et al., 1997). Under pressure from horticulturists it has been decided that study groups will be allowed to withhold and shield off new insights for a certain period of time from other NTS members. Likewise, less attention is being given to the support of study groups and other group activities by the privatised extension service. This is not surprising as both the support of mutual knowledge exchange and the supply of knowledge to a group can be regarded as ‘spoiling’ one’s own market. These obstacles to the exchange of local knowledge – which is especially important in the field of making agriculture more sustainable – seem to reinforce the creation of parallel knowledge networks described earlier, and to bring the same kinds of opportunities and threats. In the final analysis, there is a risk that the knowledge networks within which farmers and horticulturists operate will become more restricted and less ‘open’, causing a further increase of the already high costs of obtaining knowledge. This does not seem to be an ideal situation for a transition to knowledge-intensive sustainable agriculture.

Is ecological knowledge public or private property?

One complication that can arise when attention is focussed exclusively on the idea that applied knowledge is private property, is that some subjects for research and advice fall by the wayside. This risk is perhaps greatest with environmental issues because investments in sustainability usually lead to increased costs and not necessarily to greater profits. In cases of this kind farmers do not experience any personal gain while, according to the logic of the marketplace (and the principle 'the polluter pays'), they should nevertheless be carrying the costs. At the moment, the Dutch government is investing in research and extension on such 'public' issues, but a discussion on the question of whether something should be financed by the government or by the private sector arises quickly in the current climate. A phenomenon linked to this is that extension services tend to make a strict division (as regards content, methodology and time) between private (i.e. paid for by the farmer) and public (paid for by the government) extension activities. Thus, in a group meeting paid for by the government, an extension agent is likely to put forward the government's point of view on, for example, sustainable mineral management, whereas in a private consult a rather different message may be presented. From the point of view of a market-orientated organisation this is logical enough but it will probably not lead to a coherent and integrated approach towards making agriculture more ecologically sustainable.

Shifting client-perceptions within centralised applied research

Due to considerations of efficiency and the idea that applied research should not fulfil any extension functions (e.g. in the form of 'demonstration' research), quite a number of experimental farms have been closed down over the last few years. Applied research has thus become ever more centralised. It is reasonable to assume that this has led to a decrease in routine contacts between applied researchers and farmers. At the same time other parties in the production chain can be seen to be forming an increasingly important (and relatively well-resourced) customer group for applied research. Even if this may be in line with the above mentioned government policy to 'open up' the knowledge network, such changes seem to be at loggerheads with the intensive co-operation and communication between applied researchers and primary producers that is so desirable for the 'ecologisation' process.

Risks with regard to the pro-activeness and pertinence of collective (applied) research

The efforts to create a knowledge market have meanwhile changed the focus from extension to research. Applied research has lost its 'lump-sum' financing since the beginning of 1998 and will have to go looking for contracts on the research market. Similar changes have already taken place within the institutes for strategic agricultural research, and go along with the legal independence of research organisations from the state. Although in principle the funds necessary for 'collective' research remain available, in future financiers (government and product-boards) will act more as commissioners and will clearly indicate what types of research these moneys must be spent on. It is evident that the new financing system (and also the founding of Wageningen University and Research Centre) increases the control and steering capacity of the financiers, and also enables them to stimulate co-operation between different research institutes. The relevance and efficiency of research on behalf of more sustainable farming can benefit from this. An exploratory study by Van Deursen (2000) indicates indeed that actors in the knowledge network feel that the pertinence and efficiency of their work has improved in the sense that it is often much more clear and well-defined what 'product' is expected of them in the context of a particular project (that is, once it has been commissioned).

However, there is a possibility that these changes will be to the detriment of the applied nature and the pro-activeness of government-funded research. The government is no longer just the financier of the research but also commissioner and client, which encourages that solicitors of funds will follow the governments' perspective on problems in defining projects. The specific ecological problems and conditions known only to local farmers and horticulturists are thus likely to become less important as points of reference. Even if the government itself wanted to correct for this bias, they would find this difficult to achieve since –as Van der Ploeg (1999) argues-they have effectively lost their 'eyes and ears' in agrarian communities after the privatisation of the extension service. Moreover, there is a risk that a certain level of 'bureaucratisation' will occur, to the detriment of the pro-activeness of research. Nowadays more than ever before, the government – before any research can take place – will have to organise formal tendering procedures. Researchers in their turn will have to estimate whether there are funds available somewhere for a newly identified research subject, and considerable attention will have to be paid to the writing of research proposals, of which a number will not be accepted. All this will probably cause the transaction costs of research to increase. The necessity of writing and allocating working hours to paid projects can also lead to a decrease in the 'grey area' experiments conducted informally by farmers and horticulturists on experimental farms and stations. The possibility of using the 'gut feelings' and creativity of the researchers may also be limited by this; according to the study by Van Deursen (2000) this is indeed a real concern. It cannot be taken for granted that good researchers will also be good at obtaining funds, and there is a very real possibility that governmental guidance will be somewhat behind on the latest insights from research and practical experience. The question remains whether such a 'bureaucratisation' in research would be compatible with the 'ecologisation' of the agricultural sector; innovation and bureaucracy do not usually mix well (Leeuwis, 1995).

The reward structure in science

According to Bouma (1999:220), the classical separation between fundamental, basic, strategic and applied research, to be carried out by distinct and relatively isolated groups of researchers, is no longer functional. Hence, agrarian scientists at agricultural universities and institutes for strategic research can, in principle, allow themselves to be inspired by applied concerns and research questions, without devaluating scientific endeavour. Under the current reward system and culture within the scientific world, however, applicability and practice-orientation are not important evaluation criteria. Moreover, the funding of scientific agricultural research in the Netherlands takes place through separate channels and budgets than the financing of local level innovation projects, which hinders the forging of effective linkages between these domains of activity. It follows that, in terms of exact questioning and/or research set-up, scientific research often integrates better with previous research than with practical problems and real-life innovation efforts. It makes quite a difference, for example, whether the question is asked of how the migration behaviour of a useful insect can be modelled in an undisturbed environment, or how this behaviour is influenced by the various types of interim work (spraying, manual weeding, mechanical weeding, etc.).
A related problem concerns the appreciation of inter-disciplinary research. The interdependence between the ecological sub-processes means that research will have to be mostly interdisciplinary in nature. Such research is far from simple with regard to method, organisation, content and communication. Thus, 'costs' are high while the scientific recognition to be gained is dubious. It is not always easy to have interdisciplinary articles published in leading – usually single discipline – periodicals. Other forms of reward (status and promotion, for example) are also very much dependent on disciplinary colleagues and structures. In all, it can be concluded that the current reward and funding structures may be regarded as an obstacle if agricultural science is expected to make a concrete contribution to bringing about sustainable practices.

5. Does a market for applied agricultural knowledge products make sense?

Although the above analysis is based partially on provisional impressions and does not form a complete image of the workings of the agrarian knowledge network[6], there seem to be many reasons for anxiety, not least since similar concerns have been raised elsewhere (e.g. Marsh and Pannel, 1998). There seems to be a need to consider critically both the policy assumptions on which market-oriented knowledge policies are based, and the economic theories that underlie them. At this point I shall not attempt to make a full analysis, but will only introduce and reflect upon some basic elements of economic theory that are relevant in this respect.

According to economic theory, a market is a specific institutional arrangement for exchanging goods and/or services, next to other possible arrangements such as organisations or contracts (adapted from Ménard, 1995). Creating a market for a product implies that one needs to organise 'excludability'; one must be able to exclude others from the product, otherwise it is impossible to assign it with the necessary property rights and price (Umali and Schwarz, 1994; Verkaik and Dijkveld Stol, 1989; Van der Hamsvoort et al., 1999). According to economic theory, it is not always possible or desirable to use markets as an exchange mechanism (Van der

Hamsvoort et al., 1999). The transaction costs necessary for organising excludability may be excessively high in comparison with the benefits incurred. Also, the societal costs can be high, as particular groups may be excluded from the product, which may be deemed undesirable especially in the case where there is a public benefit for widespread provision of the product (i.e. the merit good argument). According to Van der Hamsvoort et al. (1999) the key advantages of introducing market arrangements for goods that used to be provided by the state (in their case 'nature and landscape') are typically that (a) the government can reduce costs, (b) one can expect a better connection between supply and demand, and (c) providers of goods can diversify their sources of income, and reduce risk. As risks they mention that (a) the provision of certain goods may be endangered as they will be substituted by goods that are easier to market (substitution risk), (b) clients will obtain goods elsewhere where no market has been organised (relocation risk), (c) certain groups will be excluded (exclusion risk), and (d) providers may incur losses and go bankrupt (market risk). In view of such advantages and risks Umali and Schwarz (1994) have identified different types of applied agricultural knowledge and information 'products', which – according to them – can be sensibly exchanged through markets. That is, they can be effectively converted into private goods (high excludability/high substractability) or toll goods (high excludability/low substractability), and marketed without severe negative consequences (Umali and Schwarz, 1994). The fact that many private and privatised extension services indeed exist and manage to create continuity seems to - at least partly- support this conclusion.

Relating this brief overview to the earlier observations, several peculiarities come to mind when considering market-oriented knowledge policies. First, we can easily recognise some of the indicated risks, in particular the exclusion risk (some farmers will be excluded from relevant knowledge), the substitution risk (research and extension will focus on those issues and/or methods for which money is easily available, that is on well-resourced clients), and possibly high transaction costs ('bureaucratisation'). These last two 'risks' particularly may well hamper the proactiveness and pertinence of the knowledge network. At the same, some of the advantages are dubious. As the government is aware that it needs to keep investing in agricultural knowledge production and exchange (i.e. neutralise some of the risks), it currently keeps its position of key funding agency for research and extension; this time in the role of client/commissioner. Thus, it is questionable if overall costs can be reduced, especially since transaction costs may rise, and commercial rates will need to be paid. The main argument that remains, then, is the supposedly improved matching of supply and demand. This might indeed be true in so far as the government and product-boards are the end-users of the knowledge products that are commissioned. However, when the purpose of knowledge production and exchange is 'grassroots' innovation for sustainable farming, improved matching is rather unlikely. As we have seen, it is only logical that client perceptions of research and extension tend to shift towards well-resourced commissioners of contracts, and away from primary producers. Moreover, the 'supply and demand' metaphor tends to foster and/or re-introduce linear thinking, and thereby obstructs the creative and flexible co-operation that is needed for local-level innovation. In conceptual terms, the key problem here seems to be that applied knowledge and information are considered as ready-made 'end-products'. However, in the context of sustainable agriculture it is probably more proper to consider applied knowledge and information as 'building blocks' of local-level innovations. For each innovation many such 'building blocks' – diverse in nature, and originating from various sources – are necessary, whereby they must be integrated and re-moulded time and time again according to local circumstances and contextual factors. Thus, each innovation requires numerous knowledge 'transactions' and exchanges. If these all need to be accompanied with payments from one party to another and vice versa (as all parties contribute relevant knowledge and information) one can wonder if such innovations will ever materialise at all.

In all, the earlier observations are in line with some conceptual doubts as to whether the capacity to innovate towards sustainable agriculture can be optimally maintained through a knowledge market. Agricultural knowledge markets may be a suitable arrangement for distributing proven, directly applicable and/or easily adaptable knowledge and information. However, such knowledge is a rare commodity in the context of sustainable agriculture. When it comes to the generation of relevant knowledge in the context of local-level innovation processes other institutional arrangements than markets are likely to be more effective.

Conclusion

At the very time that farmers are in most need of optimum support in order to change over to more complex and sustainable forms of agriculture, the Dutch agrarian knowledge network is being completely reorganised. At local level, the creation of sustainable farming practices demands creative co-operation between applied researchers, extension agents and groups of farmers. The conditions necessary for this type of co-operation seem to be deteriorating under the influence of the market mechanisms that have been introduced; hereby linear thinking, knowledge protection, internal competition and centralisation, emphasis on individual advice and changing client perceptions play a role. Also, the pro-activeness and efficiency of research and extension could be endangered by the appearance of financial barriers, 'bureaucratisation', insufficient co-operation, and the segmentation and fragmentation of research and extension capacity. There is also the threat of the ever-rising costs of knowledge acquisition for farmers who wish to use sustainable production practices (see also Renkema and Leeuwis, 1998). This is because of the eventual devolution of the various payments in knowledge networks onto the shoulders of the primary producers, decreases in 'free' knowledge exchange, and the knowledge-intensive character of sustainable agriculture.

All things considered, it is rather unclear which applied researchers and extension agents would be willing and able to facilitate on the one hand the support of the experiential learning necessary for sustainable agriculture, and on the other the interactive development of knowledge and technology adapted to local circumstances. As yet, we cannot speak of a 'hole in the market'. Rather, we witness a knowledge market that shows a great many gaps and shortcomings. This situation demands reflection and deeper research. If the above impressions are confirmed, there are two possible solution directions available. For a start, the government and product-boards can create a strong demand for the desired forms of support and co-operation. They can either commission this directly, or stimulate it indirectly, for example, by the distribution of 'research and extension vouchers' to local farmers (Richards and Van der Zande, personal comments). At the same time, this can form a stimulus for the second option, namely the creation of a strategic alliance or fusion between Wageningen University and Research Centre and DLV, the privatised agricultural extension service. This would effectively mean a reunion of key players in the agrarian knowledge network under one institutional roof, as an alternative institutional arrangement to the market. This time without the Ministry of Agriculture at the apex in the line of command.

Notes

1 In this article the term 'knowledge' is used pragmatically as a container concept for various forms in which knowledge is articulated; these include information, understanding and knowledge as incorporated in technologies and farming practices.

2 This assessment poses many questions regarding the relevance of the developed technologies for precision agriculture. It seems a little premature to develop an advanced 'tool kit' when it is still not clear whether or how it can be used. This is apart from the question of whether there might not be less capital-intensive technologies and practices which can be (or already have been) developed which lead to the desired precision, and are also linked to acceptable initial investment costs even for smaller enterprises.

3 In this way many projects are divided into steps such as: a) problem identification; b) analysis of causes and alternative solution; c) making a goal hierarchy; d) drawing up an (research) action plan; e) execution of plan, and f) evaluation.

4 If a negotiation model is taken as a basis, for example, a phasing system emerges that is completely different to the conventional problem-solution model. An applied design process could therefore arise from the following (iterative) steps (see also Leeuwis, 1999): a) preparatory research and composition of a workable team; b) establishment of the 'negotiation' procedure, rules of conduct and a provisional agenda;

c) exploration of different perspectives, interests, aims, problems, criteria, solution directions, etc.; d) manoeuvring (give and take) in the direction of a joint research plan; e) achievement of a consensus on the form of the plan; f) approval of the plan by the respective constituents; g) actual implementation and monitoring of iterative research (prototyping) linked to communication with constituents, and h) re-negotiation according to result. When the design processes are seen as negotiation processes, proven negotiation principles also become relevant (see e.g. Fisher and Ury, 1991; Van Meegeren and Leeuwis, 1999).

5 Research on learning processes regarding nutrient management problems (Stolzenbach and Leeuwis, 1996) showed, for example, that the 'forced' nature of the learning process obstructed a serious interest in content regarding nutrient cycles and management.

6 The picture painted is selective, for example, in that it focuses mainly on the 'traditional' players in the agrarian knowledge network, and makes use of qualitative impressions rather than quantitative analysis of, for example, developments in research and extension budgets. As yet, the author has not had the opportunity to engage in a more systematic enquiry.

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