Agriculture in the Information Society is analysed by a review of recent publications on the subject. The development of a future Network Society is foreseen to imply significant changes in the use of information technology (IT) in agriculture. Farmers’ hitherto modest use of IT is explained by the economic argument, that simplification of farming methods and application of cheap externally produced inputs have been more efficient ways to reduce farming costs than IT. It is predicted that this situation will change due to restrictions on chemicals and certain production practises. Information technology will become important due to a need for a higher precision in the use of chemicals and in the care of farm animals, and due to demands for food documentation. The restrictions and demands will be enforced by governments and by the food industry. Farmers will want IT applications that support the operational aspects of farming, i.e. real-time decision support on high-bandwidth wireless Internet connections. E-mail and chat applications enriched by photos, videos and sound will become important elements in a revived agricultural extension service in a future Network Agriculture.

1. Introduction

The Information Society is, in the general opinion, about to force fundamental changes in business and private life. The Danish Government, for example, is handling this as a very serious challenge and is proposing new initiatives to prepare the Danish people, business and administration to a Network Society (Castells, 1996), in which all essential matters will use on-line communication (Dybkaer and Lindegaard, 1999). High-bandwidth wireless Internet connections, expected within a few years, will allow users to be connected wherever they are. E-commerce, in particular, is expected to produce major changes in business, and extensive use of electronic communication in the public services will change the industries’ and the citizens’ interaction with the administrative bodies.

How and how much will the Information Society or the Network Society influence agriculture? There are no reasons to expect other than farmers and agro business will use IT at a similar rate as other groups of the population and other business areas, but will this produce fundamental changes in farming methods, systems and organization? So far, the changes in agriculture has mainly been driven by technological developments in farm machinery and equipment, improved crop and animal genetics, and improved feeding, fertilizing and plant protection practises. The use of IT does not seem to have been a significant factor for the changes that agriculture has experienced. One exemption may be the dairy breeding sector, which since the late 1960s has been based on an extensive collection of production data from dairy herds and a subsequent data analysis to identify bulls with superior genetic potentials.

The purpose of this paper is to identify the major IT-induced changes in agriculture that may be expected, the possible impacts of these changes, and the challenges a realization will put on the agricultural IT development society. A main source to the reflections in this paper is the recent Second European Conference of the European Federation for Information Technology in Agriculture, Food and the Environment (Schiefer et al., 1999).
2. Farmers’ use of information technology

The farmers’ uptake of IT is disappointingly modest, even for applications that have demonstrated economical benefits (Gelb, 1999; Parker, 1999). This lack of interest in IT by farmers is often explained by factors such as low levels of education and relatively high age. Ascough et al. (1999) did, however, find very complex associations between farmers’ use of IT and their education, age and experience; it seems that a main reason for using IT was a lack of agricultural competence, whereas the most experienced farmers did not seem to find significant benefits from the IT applications available to them.

Kuhlmann (1999) offers an economic explanation to farmers’ reluctance concerning IT: the farming costs are simply more effectively cut by reducing the production depth and simplifying farm operations than through extensive IT applications. Application of standardized farming procedures including purchase of relatively cheap standardized inputs is the best choice for farmers to increase production and reduce costs. For example, the costs of routine pesticide treatments are small compared to the risk of the possible losses.

Öhmler et al. (1998) found in a study on farmers’ decision-making processes that farmers do not use the linear decision model, which is usually implemented in agricultural decision support systems, but rather use non-linear decision models, continuous updating of plans, quick and simple analysis and incremental implementation. As a consequence, the IT applications available to the farmers do not fit their needs.

The modest interest in IT is also true for the newly established Internet services for agriculture (Översten et al., 1998; Offer, 1999; Jensen et al., 2000). Finland is considered to have the world’s highest penetration of personal computers and Internet connectivity, but only 3% of Finnish farmers use Internet applications for business purposes (Översten et al., 1998). Rosskopf (1999), however, reports more optimistically on the use of computers and Internet in dairy farming in New Zealand. There is an interesting similarity between farmers’ acceptance of these early Internet services and of the agricultural video text services of the 1980s (Harkin & Landau, 1997): the main interest is on volatile information such as the weather and market prices, and only modest numbers of the farmers find it worthwhile to use.

In conclusion, IT has not penetrated farming to an extent that has made any significant changes in farming systems. Information technology is used for accounting purposes and to some extent in automation, in particular in feeding equipment and in-door climate control.

3. Agricultural extension services in the information society

One of the expected effects of the Information Society is that intermediaries are made obsolete as mere ‘information pushers’ and will disappear. People will find information, buy tickets, and books, travel and arrange bank affairs by the Internet. There is no longer any need for the expensive personnel that used to offer these services face to face. Will the same thing happen to the agricultural extension services? After all, the extension service do mainly collect information from various sources and forward custom-tailored, combined information to the farmer; could this not be done cheaper and more rapidly on the Internet?

The problem is visualized in Fig. 1. A web server provides, in this example, information on plant protection issues, mainly plant pest and disease warnings and weather forecasts (Jensen et al., 2000). The server is maintained on a national level by a research institute and a central advisory centre. Farmers can then attain the information directly, by-passing the local extension officer. With the current use of the Internet by farmers the risk may not seem very large, but this may change in time.

There are no reasons to believe that the mechanisms of the Internet, which make certain types of jobs redundant, will not apply to agriculture. The question is to what extent the Internet-based information can replace the information provided by local extension officer. The strength of the Internet is that data can be collected from many sources, processed scientifically by approved models and presented to the farmer, all in real time. This will work fine to the extent that the required data and models are available. The strength of the extension officer is that he may provide advice on most problems based on human intelligence and the experience collected from the customer he serves, even when data and models are sparse.

Both types of information will be needed and the real problem is to combine them. Thysen et al. (1999) gave local extension officers an opportunity to upload text-based comments to model outputs in the plant protection service described by Jensen et al. (2000), but this was not successful. The local extension services in Denmark seem to prefer to run their own web services. Thysen et al. (1999) conclude that it may be a better solution to provide the model-based information in web components, which can be included in web pages provided by the local extension offices. This will enable these to provide externally produced information in combination with farm visits, group discussions, meetings and direct consultations.

The agricultural extension services are not mere ‘information pushers’ but also information producers.
Jensen et al. (1999) describe a web-based system for the selection of variety in field crops. New varieties are tested in trials conducted by local extension offices in Denmark, the trial data are transferred electronically to a central database and the results are made available on the Internet. The remarkable result is that the selection of a variety for a new winter wheat or winter barley crop can be based on data from the previous season’s crops, even the time spell between harvest and sowing is only a few weeks.

4. Agri chains

Agri chains are becoming an increasingly important aspect of food production and IT is the basic requirement for operating the chain (Beers, 1999). Boeve (1999) describes an interesting example of integrated chain management in the veal sector. A key part of the chain is the proprietary Integrated Veal Information (IVI®) system by which data on the individual calf is collected from the birth to the end product. All data are transferred via the Internet to a central computer from which the customers can retrieve the information they need. The customers are typically supermarket chains who access the information in a closed system. It is evident from the very limited information available at the public website (www.petersfarm.com) that information to the consumer is not significant to the chain. During the oral presentation, Boeve described how the chain had prevented the loss of a major customer, who feared dioxin-contaminated food, by the documentation on feeds used at the veal-producing farms.

This example of an agri chain reveals an important effect of the Information Society on agriculture:

- the network capabilities make it feasible for the agri chain to implement a complete information system covering food products ‘from the plough to the plate’;
- a complete traceability is expected by the supermarket chains who will react negatively if the agri chain is unable to document healthy food production in any given case;
- the agri chain will protect itself from the loss of customers by reinforcing the information system at each link, including at the farm level and
● the farmer accepts the increasing transparency in his daily operations in order to obtain higher prices for his products.

Traceability is a key word in agri chains and IT is the means to obtain traceability, as demonstrated by examples within cattle production (Offer et al., 1999) and egg production (Schwaer et al., 1999). Besides the commercial agri chains, traceability concepts (Dorp, 1999) are being implemented in national and European Community food health control schemes.

5. Farm management in the network society

In the Network Society, the farmer can connect to the network from any place he wants, by powerful wireless communication links. He can monitor any aspect of the farm, because all farm machinery and farm equipment, even farm animals, are provided with miniature computers and connected to the network; he may install various kinds of sensors at any place he wants and access them at any time; and he may access any data he wants from outside sources.

In Japan and Korea, pioneering work has been done in greenhouse farming. Shin et al. (1999) connected the greenhouse climate control computer to the Internet and made the data and functions available for remote control. Nonomiya and Kouno (1999) extended the same configuration with a remote-controlled camera, making it possible to obtain a visual impression of the crop conditions; this is perceived as a valuable marketing feature. Hatou et al. (1999) developed specialized image-compressing techniques for plant diagnosis in Internet communication.

Computing abilities by means of microchips have become essential in much farm equipment and machinery, e.g. automatic feeding, in-house climate control and self-adjusting field machinery. It is not difficult to envisage that these small computers will have networking abilities in the future. The farm manager will then have remote access, and he may monitor and control the function of automatic systems from anywhere.

A particularly interesting development may occur in animal husbandry. Technology will allow sensors and computers to be attached to or implanted in farm animals (Rossing, 1999). An electronic herdsman may then have an extensive knowledge on the location by global positioning systems (GPS) and on the health and welfare situation of individual free ranging cows, sows or sheep. In case of critical situations, the electronic herdsman may, for example, retain the animal at a feed suspensor and alert the farm staff by a cellular phone call. It may even be possible to train animals to respond in predefined ways to impulses released by the electronic herdsman or by an implanted computer, a kind of second brain, which forces a suitable behaviour of the animal. The perspectives of such a development are higher animal welfare and higher environmental consideration, because the need to keep a tight control on farm animals favours systems, in which animals are concentrated in relatively small, confined areas. The new technology may thus allow an economically feasible production without compromising farm animals’ natural requirement for free movement and space or the necessary monitoring of the animals’ health and welfare.

Farming in the Network Society will also mean on-line communication with external sources, at any time and place when the farmer may need it. For example, frequently updated weather prognosis and decision support derived from weather observations and weather prognosis may reach the farmer throughout the day. This may improve the abilities to apply chemicals for plant protection in a more precise way, for the benefit of environmental protection. Plant pest and disease warning systems are common in many countries and new applications to reach local extension offices and/or farmers by the Internet (Dölz, 1999; Jensen et al., 1999) have been implemented.

The farmer may seek advice where and when he needs it. He will be able to describe the problem by natural speak illustrated by photos or video recordings; time and location are recorded automatically. He may then send the problem by e-mail to the extension officer and receive a reply after some time, or he may solve the problem interactively in a dialogue with the extension officer or with an on-line decision support system. On very large farms, the farmers in the above lines may be replaced by the farm staff and the extension officer may be replaced by the farm manager.

6. Providing information

Management in agriculture is to a large extent to make decisions under uncertainty, the latter being accumulated from three main sources:

● uncertainty due to lack of data about the current state of nature;
● uncertainty due to incomplete knowledge about the biological and physical systems and
● uncertainty due to inherently random processes.

A rational decision-maker will take the uncertainty into account by optimizing the expected utility of future outcomes. He will use a perception of the probabilities of the future outcomes of feasible decisions and a perception of the utilities of the outcomes according to his risk
attitude. Farmers are generally risk averse. According to Kuhlmann (1999), the farmers have reduced risks by simplifying the production systems and using external inputs quite liberally. They have, for example, used chemicals in amounts that minimize the risk for major losses from malnutrition or diseases and pests in their crops. For the farm economy, this strategy has probably been correct because chemicals and other external inputs have been relatively cheap. The negative impacts on the environment are, however, not acceptable to the society. The liberal use of cheap external inputs is being restricted by various means, and the farmers can no longer be successful by ignoring the uncertainties.

Implementation of the Network Society in agriculture is a means to reduce the uncertainties. The previous sections of this paper have provided several examples of how vast amount of data may be collected from within the farm and from external sources. The increasingly powerful bandwidth of wired as well as wireless connections will ensure that the data flow to the decision-maker will not be the limiting factor.

More data are necessary but not sufficient. The data must be interpreted in relation to the relevant biological and physical systems in order to obtain useful knowledge about the current state of nature and to obtain useful predictions of the outcomes of possible decisions. The knowledge accumulated in agricultural research over many years must be applied to achieve useful information from data. This means that the implementation of the scientific agricultural knowledge in efficient on-line decision support systems is critical to achieve the potential benefits from the Network Society.

The real value of the current scientific agricultural knowledge for this purpose is, however, an open question. A great deal of the agricultural research has traditionally been targeted to produce knowledge about strategies, which on the average optimize the production. The effort to create experimental designs in crop trials that eliminates soil variation is an example. The intended use now is, however, to adapt input levels to a given variation. In precision farming, methods to collect information on natural variation within fields as well as equipment to apply chemicals in varying amounts are now available, but the understanding of the optimal responses to varied inputs seems to be unsatisfactory.

7. Discussion

It is often claimed that the use of IT is much lower in agriculture than in other industries because only few farmers use IT. The comparison to other industries is perhaps not quite fair. In agriculture, the primary manufacturing process is delegated to a large number of independent farms whereas workers produce the products in other industries in factories. A fair comparison would be between the use of IT by farmers and the use of IT by factory workers, and such a comparison would probably not be unfavourable for farmers. The agricultural extension and the food industry, on the other hand, are using IT to an extent, which is comparable to similar organizational levels in other industries.

The farmers’ use of IT must be looked upon from the point of view of farm economics. The majority of farmers will only use IT if they consider this to be economically beneficial. So far, farmers have in general, and probably rightly, preferred other strategies to maintain or increase profitability, for example simplification of farming methods, purchase of cheap external inputs and concentration on a few products. There are, however, reasons to believe that the economical value of IT in farming is increasing, which, eventually, will lead to a higher uptake of the technology.

The main reason to expect higher value of IT is the public concern about agriculture’s negative impacts on the environment and the widespread fears concerning food safety. These concerns by the consumers are causing governments and the food industry, firstly, to enforce restrictions on the use of assumed harmful chemicals and, secondly, to demand a precise documentation of the primary production process. Information technology will be required to ensure the optimal application of, e.g. fertilizers and pesticides, which by the restrictions will be made scarce resources, and the use of IT for food documentation will be a self-stimulating process, in which the possible of today will be the normal of tomorrow. Competition between larger agri chains will probably be a major driving force in this development.

At the same time, the purchase, implementation and operation costs of IT are decreasing. The general trend for hardware, software as well as connectivity is more value for less money. Furthermore, the multiple functions of computing and networking in the Network Society will decrease the marginal costs attributable to the farm business.

The farmers will demand IT applications, which can support their efforts to manage their farms according to the expectations from administrations and agri chains. The demand will be highest for applications that support operational management, while the interest for planning tools will be less. This is because a high precision in the use of chemicals and in the care of farm animals requires timely adjustments to variable circumstances, which cannot be predicted in advance. The main benefit of IT is therefore information about the changing circumstances and the advice on how to cope with it.

The main reason for the popularity of the Internet is probably that it allows everyday tasks, e.g. exchanging
letters, chatting, shopping, finding information and doing business, to be done in a new and better way by computers and electronic communication. The arguments above suggest that the same thing will happen with the use of IT in agriculture.

The challenge to the agricultural IT development society is to organize the flow of data and the proper interpretation of data. Farmers will need data from several external sources; the important data for a given problem should be presented together, i.e. the farmer should not have to visit several websites to find the information. This creates the difficult task of organizing a smooth collaboration among the information providers, overcoming various organizational, financial and copyright problems. The interpretation of data is most often equivalent to running some kind of a model of the biological system in question, using suitable mathematical and statistical methods. The scientific agricultural knowledge must therefore be implemented in one or another operational form before it can be used directly. Although this for a long time has been an accepted discipline in agricultural research, the resources allocated so far are probably not sufficient.

The direct communication between farmers and advisers may be renewed and revived in the network society by the popular email and chat facilities on the Internet. High-bandwidth connections from everywhere will allow text communication to be enriched by photos, video and sound recordings. Farmers will probably prefer to communicate with a human expert instead of a computer program, if this is economically and practically feasible.

An extensive future use of IT in agriculture will probably not in itself impose significant structural changes in agriculture, because the use of IT does not produce major reductions in labour requirements, and because there is no major scale effects on the implementation costs. The ongoing trend of larger and larger production units will, naturally, be supported by IT, but the driving forces will continue to be mainly the financial aspects of farming.

Direct sale of agricultural products from farms may very well thrive with e-commerce but will probably remain a niche production, while the main trade will remain within more and more powerful agri chains.

8. Conclusions

Farmers’ hitherto modest use of information technology (IT) is explained by the economical argument, that simplification of farming methods and application of cheap externally produced inputs have been more efficient ways to reduce farming costs than IT. It is predicted that this situation will change due to restrictions on chemicals and certain production practises. Information technology will become important due to a need for a higher precision in the use of chemicals and in the care of farm animals, and due to demands for food documentation. The restrictions and demands will be enforced by governments and by the food industry. Farmers will want IT applications that support the operational aspects of farming, i.e. real-time decision support on high-bandwidth wireless Internet connections. Email and chat applications enriched by photos, videos and sound will become important elements in a revived agricultural extension service in a future network agriculture.

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