The Bichel Committee 1999

Report from the Bichel Committee - Organic Scenarios for Denmark

Report from the Interdisciplinary Group of the Bichel Committee

Miljøstyrelsen
Miljø- og Energiministeriet

Preface

The committee to assess the overall consequences of phasing out the use of pesticides – the so-called Bichel Committee – was asked in the spring of 1998 to extend its brief to include an assessment of the overall consequences of a total restructuring of the agricultural sector for organic production.

The Bichel Committee therefore appointed an interdisciplinary group with representatives of the sub-committees on agriculture, environment and health, production, economics and employment, and legislation, to prepare scenarios for 100% organic farming. The group's task was to facilitate the cooperation between the sub-committees and prepare a combined report, although the sub-committees retained the scientific responsibility for their respective areas.

The present report describes six organic scenarios for how a 100% organic farm might look and the consequences of such restructuring for agriculture, the rest of society and the environment.

The report is one of five specialist background reports that form the basis for the Bichel Committee's final report to the Minister for Environment and Energy. The four other background reports cover the consequences for agriculture, for environment and health, and for production, economics and employment, and the legal possibilities of phasing out the use of pesticides.

This is the first time in Denmark – and probably also internationally – that such an extensive interdisciplinary analysis has been carried out of the consequences for agriculture of total restructuring for organic production.

The analysis shows that total restructuring for organic production would be a drastic change and would lead to considerable restrictions on production compared with the present situation. The consequences of such restrictions are described in this report. However, such a drastic change would undoubtedly also trigger innovations and adjustments that are not included in the scenarios presented here.

The analysis shows that compulsory restructuring for 100% organic production in Denmark within the current framework would hardly be possible. However, there is a growing market for organic food products, which is resulting in increasing restructuring of the agricultural sector. This analysis of the consequences of total restructuring will therefore shed light on the consequences of the continuing trend towards more organic production and can thus be included in the basis for political decisions on public regulation of Danish agriculture.

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1 Summary

Total restructuring for organic production in Denmark would be possible, although the level of production would be lower than it is today. However, the expected consequences would depend on how organic farming might look and thus on the assumptions on which it is based.

Six organic scenarios have been prepared:
with a 30-year time horizon
To provide a basis for assessing the consequences of total restructuring for organic production in Denmark, the interdisciplinary group has worked with six 100% organic scenarios with a 30-year time horizon. A time horizon of 30 years has been chosen because of the extensive structural changes that would have to be made in all cases. Assumptions include an even distribution of manure and use of the clover grass acreage for grazing, which in turn implies a more even distribution of livestock production over the entire agricultural area. Extensive “deregionalisation” of Danish livestock production is thus assumed in connection with the restructuring for organic production. In the economic analyses it is similarly assumed livestock would return to Eastern Denmark as the livestock housing in the western parts of the country wears out. We have therefore not assumed any costs in the form of "scrapping" of livestock housing capital in connection with the deregionalisation.

Scenarios represent mainly limitations
- and, to a lesser extent, possibilities
The chosen scenarios represent mainly the changes that can be foreseen today on the basis of the *limitations* that lie in 100% organic production as a consequence of an expected fall in the level of production. On the other hand, it has not been possible to the same extent to represent the *possibilities* that lie in 100% organic production because they depend greatly on innovations. However, possibilities for an improved level of yield in cereals and grass compared with current organic practice are included. Total restructuring for organic production is a very drastic change and must be expected to involve adjustments and innovations that are not included in the scenarios analysed in the following. In the case of some factors, an assessment has been based on relatively limited experience.

According to the current rules on organic farming, such farms must purchase conventional feed in quantities corresponding to 15-25% of the animals' daily feed intake (measured as the energy in the feed) and a certain percentage of conventional manure. In a 100% organic Denmark, there would be no conventional farms from which to purchase manure or feed, although it would be possible to import both organic and conventional feed. Three levels of feed imports to Denmark are used in the organic scenarios:
There are three levels of feed imports

- no import, complete self-sufficiency in feed
- 15% imported for ruminants and 25% for non-ruminants
- unlimited import of feed and maintenance of the present level of livestock production (1996).

On the basis of the current rules, 15-25% of the import is assumed to be conventional feed and the remainder organic feed.

- and two yield levels
The scenarios use two different yield levels in the main crops, i.e. cereals and grass: the “present yield level” based on current organic practice, and an “improved yield level”, in which it is assumed that cereal production could be increased by 15% and clover grass production by 10%. This is based on a more goal-oriented effort to increase cereal production and better use of pastureland as a result of the lower yield of the individual dairy cow compared with present organic practice. The three levels of feed import and two yield levels are expressed in six different organic scenarios:

- six scenarios in all

Present level of yield			Improved level of yield		
0% import	15-25% import	Unlimited import	0% import	15-25% import	Unlimited import

No export of plant products
Plant products are produced for domestic consumption in all the scenarios, but no plant products are exported, in contrast to today's situation, in which the net export of grain accounts for almost one fifth of the harvest and in which there are significant exports of seeds, sugar and potato starch.

-milk and beef as now
- while pork varies
The production of milk and beef could be sustained at an almost unchanged level through adjustment to feed that contains more coarse feed. Pork and poultry production would vary in step with imports of feed and productivity in plant production. In the case of 0-import, production would drop to about 30-44% of present production and, for 15-25% import, production would drop to 71-93% of present production. In arable farming, feed is produced for the above-mentioned livestock production, and plants are produced for current human consumption. It is assumed that cereal and seed grain of sufficiently good quality can be produced since the early generations are assumed to be dressed with pesticides until new organic production methods for seed grain are developed and implemented.

Necessary to import potassium
The scenarios indicate a number of constraints on a total switch to organic farming. The main constraint is probably that, in all the scenarios, it is estimated that it would be necessary to import potassium in the order of magnitude of 60 to 100 mill. kg K per year (most in the 0-import scenarios) in order to maintain yields in clover grass at the level of the empirical basis for the scenarios. In coarse sandy soil, potassium leaches easily and has to be added. There are unexploited possibilities for recirculation from urban communities in the organic scenarios, but the quantities would be relatively small compared with the need for potassium. Besides potassium, it would be necessary to import feed phosphates for the animals, also in the 0-import scenarios, to meet the animals’ needs. That means, on the other hand, that there would be no problems with the nutrient balance for phosphorus. Under

the current organic rules it is permissible to purchase feed minerals and sparingly soluble mineral fertiliser.

Import of feed is important to nutrient balance

To summarise, the loss of phosphorus and potassium through sales products must be made up for by a supply to farmland in the form of mineral fertilisers, recirculation or feed. Nutrient import via feed thus plays a significant role in the organic scenarios. As mentioned, the current rules allow use of 15% conventional feed for ruminants and 25% for pigs and poultry. However, a discussion now going on in the EU indicates that permission to use conventional feed will be withdrawn over a period of years. In such case, the need for imported feed will have to be met with organically cultivated feed. If feed were supplied to 100% organic farms in Denmark, there would be a corresponding loss from farms elsewhere in the world, which would shift the nutrient problem but not solve it. It has not been clarified how the exporters of organic feed in other countries would be able to achieve nutrient balance so that a larger organic export of feed to Denmark could be maintained in the longer term. It is therefore uncertain whether it would be possible to maintain the present quantity of exported pork from a 100% organic agricultural sector in Denmark.

Particular problems in fruit, vegetables and special crops

Organic production of fruit, certain special crops and individual vegetable species is particularly problematical. In conventional operation, larger quantities of pesticides are used in these crops than in ordinary farm crops, and the financial value of using pesticides is high. There could also be difficulties with storage and shelf life and, thus, the length of the season. For vegetables, the increased yield variation would be a problem in itself, due to the high establishment costs and the accompanying economic risk.

- and in ornamental greenery

It is difficult to use and transfer the rules for organic production of agricultural and horticultural products to the forestry sector because the time horizon and the production period within forestry are very long, with continuous value growth throughout the production period. However, problems can be expected with national monuments in old forest areas, where there is little possibility of mechanical weed control, and it can be concluded that production of organic ornamental greenery and Christmas trees on a large scale would be difficult and would require extensive development work.

Nitrogen transformation reduced
- and the contribution of nitrogen to the soil is reduced

The nitrogen cycle is significantly reduced in the organic scenarios, to a level corresponding to Danish agriculture in the 1950s, because nitrogen would not be imported in the form of artificial fertiliser. It would instead be obtained by symbiotic nitrogen fixation in clover grass fields and through importation of feed, but cereal production would be limited by nitrogen in all the scenarios. The calculations show a 50-70% reduction of the net contribution of nitrogen to the soil in the organic scenarios compared with Danish agriculture in 1996. One would therefore have to expect a significant reduction of nitrogen leaching in the long term, retaining the same cultivation practices. It should be noted, however, that the calculations are encumbered with great uncertainty.

Energy and greenhouse gases
The consumption of fossil energy and emission of greenhouse gases would fall in step with the scale of livestock production. The fall in Danish pork exports would presumably be balanced by an increase in production in other countries. Restructuring Danish agriculture for organic production would therefore not necessarily reduce global energy consumption even if Denmark's CO_2 account were improved. Energy consumption per unit of plant and livestock production would fall, mainly because of the changed composition of crops at a 100% organic farm and because industrially manufactured nitrogen fertilisers would not be used. On the other hand, if some of the crops were used for energy purposes, there would be a bigger net energy production in conventional arable farming because of the higher yield.

Increased natural content
A complete switch to organic farming would result in larger quantities of flora and fauna in crop rotation fields. Species diversity would gradually increase, although mainly in species that are already rather common. The biggest qualitative effects would be found in semi-natural ecosystems and in small biotopes because there would no longer be any spreading and drift of pesticides or unintentional delivery of top-dressed artificial fertiliser to edge biotopes.

A considerable increase in the quantity of organisms in the soil can be expected with a switch to organic farming, mainly because of changed crop rotations, and that would affect the structure of the soil, the release of nutrients and the food basis for large parts of animal life in and over the earth.

The consequences for public health of a total switch to organic farming would depend on changes in the intake of physiologically important substances. Some changes could be expected in the content of physiologically important substances, but they would be generally small in relation to the effect of changes in the composition of the diet.

Use of antibiotics is falling
Use of antibiotic growth promoters would end altogether with a total switch to organic farming. It should be mentioned, however, that the use of growth promoters in conventional farming is going to be phased out in 1999. Overall, it is estimated that the consumption of therapeutic pharmaceuticals would fall by around 30% with unchanged livestock production and further still with falling livestock production. Discontinuation of use of growth promoters is presumed to reduce the risk of transference of resistant genes to bacteria pathogenic to humans.

An established market
Today, there is an established market for organic food products. Approx. 3% of all Danish food consumption is organic and the share of the market ranges from 0-22% for different products. It is characteristic that the biggest market shares are gained for relatively cheap food products, such as milk, potatoes and vegetables. For processed products, such as meat, cheese and butter, the market shares are small.

- with price premiums
The price premium for organic products also varies greatly – from 5 to 90% for the farmer in relation to corresponding, conventional products. In the longer term, it is estimated that a price premium for the consumer of maximum 10-25% would enable continued growth in the market share of organic food products. However, for a growing market for organic food to materialise, the consumers would have to compose their consumption not only with a view to satisfying their material needs but also with consideration for their own values, including an interest in the production process in food production.

Socioeconomic consequences difficult to predict
It is extremely difficult to predict the socioeconomic consequences because the change is a very big one, with both primary production and a number of associated sectors affected to a greater or lesser extent.

A number of analyses have been carried out with a socioeconomic model that primarily throws light on the costs that would arise from the fall in primary production. The analyses are based on a "compulsory" switch to organic farming because that would be the only sure way of achieving 100% conversion. Any preferences the Danish consumers may have for organic farming have thus not been valued. On the other hand, a sensitivity analysis has been carried out in which it is assumed that foreign consumers' preferences change to the benefit of Danish organic products.

Impairs the national economy
The socioeconomic analyses show that 100% organic farming in Denmark with unchanged consumer preferences would impair the national economy. Gross National Product (GNP) would be reduced by 1-3%, corresponding to a reduction of DKK 11-26 billion per year. Private consumption would be reduced by 2-5%, corresponding to DKK 1,900-4,700 per capita per year.

The effect would depend on feed imports and productivity in primary production. 0-import and present yield level would result in the biggest reduction, while 15-25% import and improved yield level would result in the smallest reduction.

The different agricultural sectors would be affected very differently. For example, dairy farming would remain largely unchanged, whereas pig farming and arable farming would be very badly affected. These changes would affect farm economy in dairy farming, pig farming and arable farming.

- depends on consumer preferences
A sensitivity analysis has also been carried out in which changed consumer preferences in the export markets are assumed, corresponding to a price premium of 10% on milk and 20% on pork. This analysis has only been carried out for 15-25% feed import and improved practice. The analysis shows that this would reduce private consumption by about DKK 500 per capita per year and that the GNP would be reduced by DKK 8.5 billion per year.

- and valuation

A valuation has been carried out of the quantifiable environmental benefits of omitting pesticides, reducing nitrogen leaching and reducing emissions of greenhouse gases. There are big differences in the different groups' willingness to pay for environmental benefits, and the valuation here is based only on alternative costs in the form of society's savings in connection with the conversion. The analysis shows that the alternative costs of the environmental benefits can be put at DKK 1-1.5 billion per year, but it should be noted that the valuation is very uncertain.

- environmental gains can also be based on government regulation
A market-driven conversion coordinates demand and price
The socioeconomic analyses show that the costs of compulsory 100% conversion are high. If one instead allowed demand and the price mechanism to govern the rate of conversion, there would be no guarantee as to how much would be converted, but it can be assumed that the conversion that did take place would improve society's welfare. That is because, according to current economic theory, a market-driven change is synonymous both with a more effective resource allocation in society and with the consumers, through their change of preference, individually assigning the "right" value to organic food products, corresponding to their willingness to pay. Since a switch to organic farming is associated with beneficial environmental effects, it need not be based on market forces alone in order to improve the welfare of society, but can be based on government regulation.

Compulsory conversion hardly likely
- and imports cannot be banned
The Sub-committee on Legislation has considered some legal questions concerning possible restructuring of Danish agriculture for organic production (chapter 8). It is concluded that, with the current EU rules, it would hardly be possible to implement compulsory conversion. It is not possible to prohibit the importation of conventional or organic feed or food products. As long as the current EU rules remain in force, the most realistic scenario would be voluntary conversion to organic production. The sub-committee also indicates some legal initiatives that the Danish government could take in an EU context to promote conversion to organic production.

In this report, the organic scenarios are based on a number of assumptions that can be discussed in connection with the perspectives for organic agriculture in Denmark. The main assumptions can be divided into two groups, as follows:
Interpretation and form of production

⇕

and preference for organic production

1. The organic form of production, which in turn depends on the interpretation of organic farming's basic concept, including legislation and rules on imports and self-sufficiency in fertiliser and feed.
2. Society's interest in and the consumers' preference for the organic form of production.

- are related to the precautionary principle
The trend in organic production has hitherto been based extensively on changes in consumer preferences to the benefit of organic products. This

change in consumer preferences may be connected with a conscious or unconscious use of a preventive or precautionary principle based on the consumers' experiences with the use of new technology in farming.

- sustainability

Involvement of the precautionary principle is bound up with a perception of nature as more or less fragile and acceptance of man as an integral part of nature. In the form of the concept "sustainability", this insight has gained a big foothold in the national debate.

- and perception of nature

Organic farming is based on a different perception of nature than the one that has dominated in conventional farming. This difference in the perception of nature leads to a different approach to food production and prevention of environmental problems. Seen in this way, organic farming would do more to prevent environmental problems than conventional farming, but, the level of production and productivity would be lower. Organic food production would therefore involve more production costs. However, it is estimated that it would be possible to improve the efficiency of organic farming in the long run, although this would depend on organic farmers wanting a development in which the rules are generally up for debate but naturally with proper respect for organic farming's values.

Compulsory restructuring or market-driven conversion

The cost of compulsory total restructuring would be high. If one instead allowed demand and the price mechanism to govern the rate of conversion, there would be no guarantee as to how much would be converted, but it can be assumed that the conversion that did take place would improve society's welfare. Since the change would be linked to beneficial environmental effects, it would not need to be based on market forces alone to improve society's welfare.

Government regulation and changed subsidy schemes increase conversion

It follows from the above that the impact on the common environment from agriculture constitutes grounds for government regulation and that increasing the rate of conversion may be warranted. In continuation of that, the trends in international agricultural and trade policy will be of importance. For example, the current trends point in the direction of unlinking subsidy and production quantity and towards higher prioritisation of environmental objectives. These perspectives may imply incentives for a continued expansion of organic food production.

As far as the market perspectives are concerned, continued high prioritisation of the environment and livestock welfare is presumed to lead to continued growth in the demand for organic food products. The reason why this prioritisation is assumed to be primarily addressed to organic food products is that only organic farming is based on a clear and internationally recognised concept.

if the players agree

All in all, it follows that the development perspectives will depend on market conditions and political decisions. However, in addition to that, it must again be stressed that the development perspectives also depend on whether relevant players agree on and are motivated for a conversion of the extensive network of companies and institutions of which agriculture is a part.

- and reduce the use of pesticides

With respect to society's current possibility of reducing the use of pesticides, organic farming is an obvious option. If the development continues as hitherto, about 20% can be expected to have been converted by the year 2008, which will result in a 14-18% reduction in the average treatment frequency compared with present practice. As long as there is a market prepared to pay a premium for organic products, that will be the socioeconomically cheapest solution.

2 Introduction

This work is part of the Bichel Committee's mandate
In a letter dated 26 February 1998 to Svend Bichel, the Minister of Environment and Energy requested the committee appointed to assess the overall consequences of phasing out the use of pesticides (the Bichel Committee) to incorporate a project in its work with a view to an assessment of the overall consequences of a total restructuring of the agricultural sector for organic production. The reason for this was that in association with the Finance Act for 1998, the Government, the Socialist People's Party and the Red Green Alliance (Denmark) agreed to reinforce efforts for protecting the aquatic environment and for promoting restructuring for organic production. In that connection, a sum of DKK 2 million was set aside for developing scenarios for assessing the overall consequences of a total organic restructuring of agriculture.
The work on the organic scenarios follows the mandate of 4 July 1997 for the above-mentioned committee.

2.1 **Organisation of the work**

An interdisciplinary group was appointed
To ensure coherence and an integrated approach in the work on the organic scenarios, it was found that a slightly different form of cooperation was needed between the specialist sub-committees than in the work on phasing out the use of pesticides. The coordination group under the Bichel Committee, which is composed of the chairmen of the main committee and the sub-committees, therefore appointed an interdisciplinary group with one participant from the Sub-committee on Legislation and two from each of the other sub-committees.

Scientific responsibility
The group's task was to prepare a proposal describing the work needed and subsequently to follow up on its implementation and present a combined report. The work was based on the existing structure of the Bichel Committee. The scientific responsibility for the various chapters in the report lay with the respective sub-committees. The Sub-committee on Agriculture was thus responsible for chapter 5 (Agricultural consequences), the Sub-committee on Environment and Health for chapter 6 (Consequences for environment and health), the Sub-committee on Production, Economy and Employment for chapter 7 (Consequences for production, economics and employment) and the Sub-committee on Legislation for chapter 8 (Legal aspects). Responsibility for the remaining chapters lay with the coordination group.

The main committee and sub-committees were kept informed during the work to enable decisions to be taken concerning any deviations from the original plan. This report was discussed at the sub-committees' meetings in January and February 1999 with a view to scientific assessment and approval of the results within the respective committees' areas.

The interdisciplinary group comprised:
The members of the interdisciplinary group:
Johannes Nebel, farmer, Sub-committee on Agriculture
Lisbeth Frank Hansen, consultant, Sub-committee on Agriculture
Hans Løkke, Director of Research Department, Sub-committee on Environment and Health
Dr. Lars Ovesen, Head of Division, Sub-committee on Environment and Health
Alex Dubgaard, Reader, Sub-committee on Production, Economics and Employment
Jan Holm Ingemann, Reader, Sub-committee on Production, Economics and Employment
Lisbeth Arebo Jacobsen, Principal, Sub-committee on Legislation
Kaj Juhl Madsen, Head of Section, Secretariat for the Pesticide Committee
Erik Steen Kristensen, Chief Scientist, Secretariat for the Pesticide Committee

The group was linked to the expert environment under the Danish Research Center for Organic Farming, in which connection Chief Scientist Erik Steen Kristensen was attached to the Secretariat for the Pesticide Committee to manage the work of the group. Assistant Research Scientist Hugo Fjelsted Alrøe, Research Center for Organic Farming, carried out a large part of the compilation of this report.

3 Organic farming today

Organic farming in:
- 1988
- 1998

- and 2003

In recent years, there has been growing interest in organic farming and organic food production. In 1988, there were 219 organic farms in Denmark, corresponding to 0.2% of all agricultural land. Preliminary figures for 1998 show 2,228 organic farms, corresponding to just over 3% of agricultural land. Action Plan II includes a forecast for restructuring up to the year 2003, when there are expected to be just over 5,000 organic farms with a total of just under 300,000 ha, corresponding to more than 10% of agricultural land in Denmark (The Ministry of Food, Agriculture and Fisheries 1999).

Growing demand
It is important to stress that consumer interest in organic products is a significant driving force behind the above trend. Despite consumers having to pay premiums of 5-90%, there is a constantly growing demand for organic food products. However, the breakthrough relates mainly to the relatively cheap products, whereas there is not as yet any significant market for organic meat.

The Danish authorities' definition of organic farming was given for the first time in Act on Organic Agricultural Production (No. 363 of 10 June 1987). The latest formulation is quoted below:

Definition and goal
"*Organic farming is based on a goal of establishing stable and harmonious operating systems in which the individual types of production can be integrated in a natural biological cycle. Wherever possible, there should be livestock on the farms. Artificial fertilisers, pesticides and growth regulators are not used, and industrially produced additives are not used in feed. The supply of fertiliser is based mainly on organic dressings, manure, green dressings, crop residue, etc. and nitrogen fixation through leguminous plants. Plant diseases, weeds and pests are controlled by well-planned and diversified crop rotations, mechanical soil preparation and a suitable choice of varieties, including mixed varieties."*
(Ministry of Food, Agriculture and Fisheries 1995, p. 51)

The main thing about organic farming is that it is based on an explicit goal of establishing stable and harmonious operating systems in which the various types of production can be integrated in a natural biological cycle. The main objectives are to work for a more closed feed and nutrient cycle, to avoid polluting the environment and to preserve/increase the fertility of the soil. In conventional farming it is only in the last few years that people have begun discussing a common goal that covers more than simply profit maximisation. See, for example “Good Farming Year 2000” (Agricultural Advisory Service 1996).

The perception in organic farming is that it is possible to use a production method that is based on a more varied crop rotation than in conventional farming, using perennial and nitrogen-fixating crops together with organic dressings, which are regarded as fundamental for organic food production. Organic farmers say: ”You fertilise the soil – not the crops”. The basic values of organic farming are described in greater detail in chapter 9.

In this introductory section we shall focus on the legislation and rules on which a model for 100% organic farming has been based.

Legislation and rules

From the very first law on organic farming in 1987, the main focus has been on the production and environmental aspects of different operating systems. However, in recent years, great attention has also been focused on the welfare and quality aspects of organic farming. (Ministry of Food, Agriculture and Fisheries 1999).

To achieve the goals, laws and rules have been issued with a view to more precise regulation of organic farming and organic food products (see, for example, the Danish Plant Directorate’s guide from November 1997, which is based on Executive Order No. 892 of 27 October 1994 on organic farming, as amended by Executive Order No. 832 of 10 November 1997, and Executive Order No. 753 of 2 September 1992 on the conditions for marketing organic food products, as last amended by Executive Order No. 1285 of 23 December 1996). The body of legislation and rules has become quite extensive, but the main rules relating to the feed and nutrient cycle are as follows:

- the use of artificial fertilisers, pesticides and growth promoters is not permitted;
- if there is insufficient fertilisation, max. 25% of the crop-specific nitrogen standard may be purchased in the form of conventional manure or a number of other types of organic dressings that are included in the positive list;
- not more than 15-25% of the feed required for livestock may be of conventional origin.

The absence of artificial fertiliser and the ceiling on feed imports significantly reduce the supply of nutrients in organic farming and thus also the size of organic livestock production.

Many organic farms are also authorised by the National Organisation for Organic Farming, which means that the amount of fertiliser that may be used must not exceed manure from 1.4 l.u./ha as an average for the whole farm. It should also be noted that the legislation and rules are still being developed. For example, an increased requirement concerning self-sufficiency in feed is anticipated.

4 Definition of the work and method

100% organic farming cannot be precisely defined
With respect to preparing scenarios for organic farming in Denmark, it must be stressed that such scenarios are far more complex than, for example, scenarios for pesticide-free farming. The reasons for the complexity are as follows:

- organic farming is based on an objective – not a precise definition;
- the rules are still being developed;
- a market has been established in which a price premium is obtained for organic products.

4.1 **Definition of the work**

- so there is a need for a process-oriented method of work
Today, only a relatively small proportion of farms are organic farms. This fact, together with the above-mentioned complexity, means that a 100% organic farm must be expected to be very different from the organic farms we know today. It has therefore been necessary to adopt a process-oriented approach, so that different possibilities for how a 100% organic agricultural sector might look can be discussed in a dynamic process. In other words, it has also been necessary to focus on how and why a given scenario can be expected to emerge because it is only through this process that a 100% organic agricultural sector can take form. For example, there has had to be a balanced discussion of the flow of nutrients to and from Denmark. If all farming in Denmark were organic there would be no conventional farms from which to buy manure, and importing manure is not a relevant option. On the other hand, one can discuss the extent to which Denmark must be self-sufficient in feed and the requirements that might have to be made concerning import of feed and other nutrients. Another advantage of this process-oriented method of work is that it produces good background knowledge on which to base any decisions concerning a desired development.

The work process was divided into two stages:
A: firstly, an objective and documented description of organic farming was prepared on the basis of various viewpoints
B: secondly, the various viewpoints and problems were combined and the different considerations were assessed.

The main committee was originally intended to assess the different viewpoints (stage B), assisted by the interdisciplinary group, which is composed of representatives from the sub-committees (see section 2.1). However, the work on stage A took up most of the resources and left less time for stage B than planned. Therefore, in this report, the planned assessment has been reduced to chapter 9 “Discussion and perspectives”.

-with several viewpoints
The dynamic perception of the work process was supported in stage A by working with different *viewpoints*. Five main viewpoints on organic farming in Denmark were used:

A.1 Farming, input and yield in different production systems
A.2 Production, economics and employment
A.3 Environmental and health-related aspects
A.4 Local and institutional aspects
A.5 Legal aspects.

These five viewpoints were chosen partly to ensure that the main and, in some cases, conflicting views on organic farming were represented and partly because of the existing structure of the Bichel Committee. The five viewpoints are dealt with in separate chapters of this report. The references for the chapters in question are: the Sub-committee on Agriculture for chapter 5 (A.1), the Sub-committee on Production, Economics and Employment for chapter 7 (A.2), the Sub-committee on Environment and Health for chapter 6 (A.3) and the Sub-committee on Legislation for chapter 8 (A.5).

As part of stage A in the work process, the following background reports were prepared:

The background reports

Agriculture

A.1.1 *Denmark's total production and input of ancillaries at 0 and 15-25% import of feed with present livestock production*
Hugo Fjelsted Alrøe, Erik Steen Kristensen and Birgitte Hansen, DARCOF.

A.1.2 *Crop rotation models – evaluation of changes in yield in agricultural crops*
Hugo Fjelsted Alrøe, DARCOF, Ib Sillebak Kristensen, Gunnar Mikkelsen, Lise Nistrup Jørgensen, DJF (Danish Institute of Agricultural Sciences), Michael Tersbøl, Agricultural Advisory Service.

A.1.3 *Production of open-grown vegetables*
Kristian Thorup-Kristensen and Lis Sørensen, DJF

A.1.4 *Feed consumption, production and production conditions in organic farming systems*
John E. Hermansen, Lisbeth Mogensen & Troels Kristensen, DJF

A.1.5 *Production of fruit and berries*
Hanne Lindhard and Holger Daugaard, DJF

A.1.6 *The supply of phosphorus, potassium and sulphur in organic farming*
Jens Færge and Jakob Magid, KVL (The Royal Vetinerary and Agricultural University)

Production, economics and employment

A.2.1 *Market perspectives for organic food products*
Bolette Abrahamsen & Jan Holm Ingemann, Aalborg University

A.2.2 *Economic valuation of environmental improvements with organic farming*
Alex Dubgaard, Christian Beckmann & Kristian Lykke Fick, KVL

A.2.3 *Analysis of the socioeconomic consequences of restructuring Danish agriculture for organic production*
Lars Bo Jacobsen & Søren Frandsen, SJFI (Danish Institute of Agricultural and Fisheries Economics)

A.2.4 *Comparison of the economy of organic, pesticide-free production and conventional production*
Pia Strunge Folkmann, SJFI

A.2.5 *Restructuring for organic production - the possibilities up to the year 2008.*
Pia Strunge Folkmann, SJFI

Environmental and health-related consequences

A.3.1 *Nitrogen and phosphorous – balances and environmental consequences*
Ruth Grant, DMU (National Environmental Research Institute)

A.3.2 *Consumption of fossil energy and greenhouse gas emission*
Tommy Dalgaard, Niels Halberg, DJF, & Jes Fenger, DMU

A.3.3 *The natural content of the agricultural landscape and dependence on form of production*
Jens Reddersen, DMU

A.3.4 *The soil's biology*
Jørgen Aagaard Axelsen, DMU, Susanne Elmholt, DJF

A.3.5 *Health consequences of plant products*
Kirsten Brandt, DJF, Niels Elmegaard, DMU, Lars Ovesen, Danish Veterinary and Food Directorate, and Vagn Gundersen, Risø

A.3.6 *Consumption of medicine and similar – environmental and health consequences*
Torben Bennedsgaard & Stig Milan Thamsborg, KVL, John Jensen, DMU, & Frank Aarestrup, SVS (National Veterinary Serum Institute)

Local and institutional aspects

A.4.1 *Local and institutional aspects*
Johannes Michelsen, University of South Denmark, & Per Kølster

A.4.2 *Decision-making principles and institutional perspectives*
Jan Holm Ingemann, Aalborg University

A.4.3 *Danish agriculture's institutional network and its potential for organic restructuring*
Jan Holm Ingemann, Aalborg University

Legal aspects

A.5 *Legal questions concerning a total restructuring of Danish agriculture for organic production*
The Sub-committee on Legislation under the Bichel Committee.

- can be ordered

These background reports have been studied and discussed in the respective sub-committees. They can be ordered from the Danish Environmental Protection Agency. For the sake of good order it should be noted that the views presented in the background reports are not necessarily those of the Bichel Committee or its sub-committees. The interdisciplinary group has used the background reports as the basis for this report on the consequences of restructuring the agricultural sector for 100% organic production.

4.2 Method

In order to draw up scenarios as a basis for assessing the consequences of totally restructuring Danish agriculture for organic production, two important methodological choices had to be made. Firstly, the goal for the scenarios had to be chosen: 100% organic production in the agricultural sector and, secondly, a base situation with which the goal could be compared.

The scenarios drawn up can be described as consistent calculations based on the available knowledge concerning agriculture today. In addition, the scenarios are based on a number of assumptions that make them scenarios for 100% organic agriculture.

A range of options -

As described above, there is no absolutely clear picture of how a 100% organic agricultural sector might look. The scenarios therefore had to represent *a range of options* for a future, totally organic agricultural sector. The scenarios differ from each other mainly with respect to the level of import of feed, resulting in differences in nutrient and energy turnover that have consequences for production, the environment and the economy.

Although with the focus on the constraints
The chosen scenarios represent mainly the changes that can be predicted today on the basis of the *constraints* inherent in 100% organic farming as a consequence of an expected fall in the level of production. It has not, on the other hand, been possible to represent to the same extent the *possibilities* that lie in total restructuring because they depend to a great extent on innovations. However, account has been taken of possibilities for an improved yield in cereals and grass as a consequence of greater focus on cereal production and better utilisation of pastureland than in present organic practice because of a lower yield from each dairy cow.

A total switch to organic farming is such a drastic change that it must be expected to lead to significant adjustments and innovations that are not included in the scenarios analysed in the following. That applies particularly to the parts of the food sector that supply, purchase, process and distribute the food products. However, these areas and the possible effect on them of a 100% switch to organic farming lie outside the sub-committee's mandate and are therefore not dealt with in detail in this report. The scenarios are based on present-day practice and knowledge and cast light on the consequences of a 100% switch to organic farming on that basis. They can thus not be regarded as forecasts of a probable development.

Comparison with present-day farming
Furthermore, in order to describe the *consequences* of a 100% switch to organic farming, it is necessary to have a base with which the future scenarios can be compared. The base chosen is farming today, i.e. 1995/96. However, for yield levels in crops a longer period has been chosen – 1993-96. The year 1995/96 has been chosen in order to have a consistent and coherent database and having regard to the basis for the assessment of the consequences of phasing out the use of pesticides.

- although this is changing
The scenarios describe a situation 10 or 30 years hence, so a comparison with 1995/96 can be objected to on the grounds that Danish farming will look entirely different in 10 or 30 years' time. Farming is changing all the time – a number of changes are expected in the very near future and changes have also occurred since 1996, including continued restructuring for organic production. These changes are mentioned where relevant and included wherever possible. However, it is important to note that changes and measures coming now or in future in the Danish agricultural sector will also have derivative – and in many cases unknown – effects. For example, when, as planned, Danish farmers phase out the use of growth promoters in 1999, that must be expected also to have consequences for production. Similarly, changes in both national and international agricultural policy will affect the development of both conventional and organic farming, but it has not been possible to include such perspectives to any great extent in the sub-committee's work.

- because a coherent basis for comparison is needed
Actual, coherent and consistent scenarios for a future Danish agricultural sector have only been prepared in a few, limited areas, such as Aquatic Environment Plan II and the scenarios for phasing out the use of pesticides. These scenarios are included as the basis for comparison in the areas covered by the scenarios. Other, individual, expected changes cannot be

included directly in a comparison with the scenarios because a complete picture of the consequences of these changes is lacking. The effects of phasing out the use of pesticides are described in detail in the other reports from the Bichel Committee. The present report should be seen as a supplement to those reports.

In the following chapters a picture is given of the consequences of a total switch to organic farming on the basis of different levels of feed import and different yield levels, as described above.

A detailed description of the scenarios and the assumptions on which they are based are given in chapter 5, together with the consequences for plant and livestock production.

Chapter 6 describes the environmental and health consequences, and chapter 7 the economic consequences, on the basis of the scenarios described in chapter 5. The legal aspects of restructuring for organic farming are discussed in chapter 8, including the relationship with EU legislation.

In chapter 9 the various aspects covered by the foregoing chapters are weighed, the chosen assumptions are discussed, and the possibilities for and barriers to achievement of a totally organic agricultural sector are described.

5 Agricultural consequences

The time horizon of the organic scenarios is 30 years
We have attempted to clarify the consequences for overall production with 100% organic farming by means of a number of scenarios that differ with respect to the quantity of imported feed and crop yield levels. A time horizon of 30 years has been chosen for the scenarios because it is thought that extensive structural changes will be needed, partly as a consequence of an assumption that the manure produced can be evenly distributed over the whole of the country and partly as a consequence of changed livestock housing systems. For an even distribution of manure and utilisation of the clover grass acreage, livestock production must be evenly distributed over the entire agricultural area. With the present, heavy concentration of livestock production in Western Denmark, extensive ”deregionalisation” of Danish livestock production is assumed in connection with the restructuring for organic production. In the economic analyses for the 30-year scenarios (chapter 7), it is assumed that the return of livestock to Eastern Denmark takes place as the surplus livestock housing capacity wears out in the western parts of the country. Therefore, the economic analyses do not include costs in the form of ”scrapping” of housing capacity in connection with the deregionalisation.

According to the current rules on organic farming, organic farms must purchase conventional feed in quantities corresponding to 15-25% of the animals' daily feed intake (measured as the energy in the feed), and a certain percentage of conventional manure. In a 100% organic Denmark, there would be no conventional farms from which to purchase manure or feed, although it would be possible to import both organic and conventional feed. Three levels of feed imports to Denmark are used in the scenarios:
- there are three levels of feed import

- no import, complete self-sufficiency in feed
- 15% imported for ruminants and 25% for non-ruminants
- unlimited import of feed and maintenance of the present level of livestock production (1996).

On the basis of the current rules, 15-25% of imported feed is assumed to be conventional feed and the remaining 75-85% organic feed.

- and two yield levels
The scenarios use two different yield levels in the main crops, i.e., cereals and grass. The yields achieved at organic dairy farms in the period 1993-96 are the basis for: "Present level of yield". Also used is an "Improved level of yield" (+15% in cereals and +10% in clover grass). In cereals, the reason for the improvement is more targeted action to increase cereal production in relation to present practice. In clover grass, the improvement is due to better utilisation of pastureland, which is possible because a low yield from each dairy cow is accepted. The chosen levels of yield are described in detail in section 5.2 and in Alrøe et al. (1998b).

The three levels of feed import and two yield levels are expressed in six different organic scenarios:
Six scenarios in all

Present level of yield			Improved level of yield		
0% import	15-25% import	Unlimited import	0% import	15-25% import	Unlimited import

Milk and egg production as now
- but varying pork production
In all scenarios, the production of milk and eggs corresponds to present production. The production of milk is limited by milk quotas and could be greater without causing agronomic difficulties. Beef is produced in relation to the number of dairy cows, in the form of cast cows, heifers and bullocks, the male animals being fattened like bullocks with summer grazing (section 5.3.1). The remaining feed is used in producing pork, since meat from poultry is included in the model as pork. The production of pork therefore varies in proportion to the produced and imported quantities of feed, and no plant products are exported in the scenarios. The production of pigs and bullocks is assumed to be as big as possible in relation to feed production and feed import in scenarios with limited feed import. As mentioned in section 4.2, these scenario assumptions have been made with a view to clarifying constraints and possibilities and must not be taken as a forecast of a probable development in practice.

Other assumptions
Production in greenhouses and the production of ornamental plants, etc., (a total of about 4,000 ha), as well as the production of fur-bearing animals, are not included in the scenarios. The assumptions and constraints of the scenarios are described in more detail in Alrøe et al. (1998a).

The scenarios describe the expected production with the chosen assumptions on the basis of the available empirical knowledge. The relationship between the choices made and their consequences are discussed in chapter 9. Section 5.1 below gives a complete picture of agricultural production in the six scenarios compared with actual agricultural production in Denmark in 1996, and a detailed description of plant and livestock production is given in sections 5.2 and 5.3.

The possibilities and problems in organic production of open-grown vegetables and fruit and berries are dealt with separately in sections 5.4 and 5.5, while section 5.6 gives a picture of organic production in forestry. Section 5.7 gives a combined discussion of the nutrient balances in the organic scenarios.

5.1 **Total agricultural production**

Land use differs considerably from present-day use
In organic farming, there are more limits to what can be grown in the way of different crops than there are in conventional farming. There must be a considerable proportion of nitrogen-fixating crops and the crop rotations must be diversified and include perennial crops. Land use in the scenarios differs considerably from present-day use. Table 5.1 shows the use of the entire cultivated area in the six organic scenarios, compared with the use in Danish agriculture in 1996.

Production in the organic scenarios

The total production of primary agricultural products in the six organic scenarios is shown in table 5.2, compared with agricultural production in 1996.

Table 5.1 *The use of the entire area under cultivation (1,000 ha) in Danish agriculture 1996 and in the organic scenarios* (Danmarks Statistik 1997, Alrøe et al. 1998a)

	Danish agriculture 1996	*Organic scenarios*					
		Present level of yield			*Improved level of yield*		
		0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Grain for human consumption		217	217	217	189	189	189
Feed grain		787	934	945	819	942	945
Seed corn		70	62	59	58	52	52
Grain, total	1,545	1,075	1,213	1,221	1,066	1,183	1,185
Pulses [a]	73	183	162	154	212	192	190
Rape	109	118	0	0	107	0	0
Seed for drilling	61	27	27	27	27	27	27
Grass in rotation	370 [b]	973	973	973	973	973	973
Fodder beets	41	55	55	55	45	55	55
Sugar beet	70	45	45	45	45	45	45
Potatoes	43	13	13	13	13	13	13
Vegetables [c]	7	11	11	11	11	11	11
Fruit, berries, etc. [c]	12	16	16	16	16	16	16
Permanent grass	384 [d]	200	200	200	200	200	200
Total	2,716	2,716	2,716	2,716	2,716	2,716	2,716

[a] The necessary acreage for pulses in the organic scenarios is given separately here, but it is envisaged that pulses would largely be grown together with cereals.

[b] Of which, total crop and maize: 101,000 ha.

[c] The acreages for organic production of fruit and vegetables depend on the choice of cultures and must therefore be regarded as an estimate.

[d] Including set-aside. Set-aside is not included in the organic scenarios.

Table 5.2 *Total production of primary agricultural products in 1996 and in the organic scenarios* (Pedersen 1997, Danish Farmers' Union 1998, Danmarks Statistik 1998, FAO 1998, Alrøe et al. 1998a)

	Danish agriculture 1996	*Organic scenarios*					
		Present level of yield			*Improved level of yield*		
		0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Grain (*mill. FU*)[a]	9,850	3,678	4,549	4,785	4,581	5,448	5,506
Grass etc. (*mill. FU*)	3,269	5,311	5,165	5,060	5,721	5,525	5,495
Fodder beets (*mill. FU*)	440	537	537	537	440	537	537
Rape (*mill. kg*)	251	271	0	0	247	0	0
Seed for drilling (*mill. kg)*	64	13	13	13	13	13	13
Potatoes (*mill. kg*)[b]	1,617	327	327	327	327	327	327
Sugar (*mill. kg*)[c]	493	225	225	225	225	225	225
Vegetables (*mill. kg*)	291	291	291	291	291	291	291
Fruit and berries (*mill. kg*)	61	61	61	61	61	61	61
Milk (*mill. kg EAM*)	4,690	4,650	4,650	4,650	4,650	4,650	4,650
Beef (*mill. kg*)	198	202	195	190	207	199	197
Pork and poultry products (*mill. kg*)	1,773	531	1,255	1,773	793	1,645	1,773
Eggs (*mill. kg*)	88	88	88	88	88	88	88

[a] Grain for feed, sowing and consumption, incl. pulses

[b] Potatoes, incl. seed potatoes (and for Danish agriculture 1996, incl. potatoes for industry)

[c] Refined sugar

In the organic scenarios, plants would only be produced for consumption and feed, while the production of animal products would exceed domestic consumer demand and some of it would be exported. The production of cereals would be considerably smaller than in 1996 and varies between the scenarios, while there would a bigger production of grass than in present-day farming. In the scenarios without feed import, rape would only be grown for feed, while in all the scenarios, seed would be produced for domestic consumption as seed for clover grass. The production of beef varies slightly from one scenario to another because the average milk yield would vary with the feed supply whereas the production of pork varies considerably.

Feed import

Table 5.3 shows the feed import to Danish farms in 1995/96 and in the organic scenarios. It will be seen that with "unlimited import", the feed import would be at the same level as in Danish agriculture today, and that with "15-25% import", it would be smaller.

- and export of agricultural products

Table 5.3 also shows the quantities that would be available for export in the organic scenarios after meeting domestic demand and the need for feed. This is compared with the export of cereals and rape and the net export of other agricultural products in 1996. Today, there is a substantial production of plant products for export – particularly cereals, rape and seed and such processed products as sugar and potato starch. Plant production for export takes up around 500,000 ha of agricultural land. If export of plants ceased, almost 20% of that area would be used for feed production instead.

Table 5.3 *Import of feed and export of agricultural products in 1996 and in the organic scenarios* (The Danish Farmers' Union 1998, Danmarks Statistik 1998, FAO 1998)

	Danish agriculture 1996 [a]	*Organic scenarios*					
		Present level of yield			*Improved level of yield*		
		0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Feed import (mill. FU) [b]	*3,513*	*0*	*2,300*	*4,158*	*0*	*2,715*	*3,176*
Grain (*mill. kg*)	2,022	0	0	0	0	0	0
Rape (*mill. kg*)	58	0	0	0	0	0	0
Seed for drilling (*mill. kg)*	61	0	0	0	0	0	0
Potatoes (*mill. kg*)	421 [c]	0	0	0	0	0	0
Sugar (*mill. kg*)	160	0	0	0	0	0	0
Milk (*mill. kg*)	2,352	2,312	2,312	2,312	2,312	2,312	2,312
Beef (*mill. kg*) [d]	96	100	93	88	105	97	95
Pork and poultry products (*mill. kg*) [e]	1,342	100	824	1,342	362	1,214	1,342
Eggs (*mill. kg*) [f]	6	6	6	6	6	6	6

[a] The figures for plant export should only be taken as an indication since there are big variations from year to year.
[b] Grain accounted for about 10% of the feed import in 1996 and would account for just over 50% in the organic scenarios.
[c] Incl. the part of the production that is exported as potato starch.
[d] Calculated as production in slaughtered weight minus consumption (102 mill. kg); excl. export of 54,500 live animals in Danish agriculture 1996, corresponding to 3 mill. kg live weight.
[e] Calculated as production in slaughtered weight minus consumption (431 mill. kg); excl. export of 692,000 live animals in Danish agriculture 1996, corresponding to 33 mill. kg live weight.
[f] Calculated as production minus brood eggs (10 mill. kg) and consumption (72 mill. kg)

In the organic scenarios, exports of milk products and beef would be at the same level as today. Pork exports would be unchanged with unlimited import. In the scenarios with the present level of yield, exports would fall by just under 40% with 15-25% import of feed and by more than 90% with 0-import. In the scenarios with an improved level of yield, pork exports would fall by only 10% with 15-25% import of feed and by just over 70% with 0-import.

Total production in the organic scenarios would depend on specific crop rotations, yields, production systems and production levels. These are described in sections 5.2 and 5.3 below.

5.2 **Production of agricultural crops**

The predictions concerning the production of agricultural crops with 100% organic farming are based on the available data from present-day organic farms. Studies of existing farms by the Danish Institute of Agricultural Sciences show that a typical organic crop rotation with cereal production can be a so-called five-field rotation:

The typical crop rotation

Spring barley with undersown crop – clover grass – clover grass – cereal – cereal/row-grown crops

It will be seen that, here, clover grass accounts for two of five rotations or 40% of the crop rotation. In practice, clover grass's share usually lies between 30 and 50%. On good cereal soil (clayey soil), one or two rotations with cereal or row-grown crops may be added, and on slightly poorer cereal soil (sandy soil), the last rotation with cereal or row-grown crops may be removed. This five-field rotation is the basis for the model on which the organic scenarios are based.

5.2.1 **The empirical basis**

The empirical basis includes different types of data -

The empirical basis for an assessment of the level of yield in agricultural crops with 100% organic farming in Denmark comprises data from different types of studies and experiments, including data from farm studies, from production or crop rotation systems at research stations, from annual reports of field trials and from accounting statistics. To be able to give the best possible estimate of the level of yield that could be expected with 100% restructuring for organic farming, it is important to assess the background for the different types of data (Alrøe et al. 1998b).

- each with strong and weak sides

The different types of data each have their strong and weak sides. Data from privately owned farms tell something about the levels of yield that are achieved in practice, but without data from a substantial proportion of all types of farm, it is difficult to use those data to say anything about the general level of yield. Farm studies are useful because they provide detailed information on the farms in question that can be used to assess the measured yields as a basis for saying something about the expected yield level at farms like those in the studies. However, the extensive registration needed limits the number of farms that can be studied and thus the possibility of generalising the results. Data from research stations are even more detailed than the data from the farm studies so even fewer farms are covered. Research stations necessarily differ somewhat from the average farm in practice in several ways, including having the possibility of almost optimum farm management and fewer limitations on manpower etc.

The best basis

From an analysis of the empirical data it has been found that the best basis for calculating the expected yields with 100% organic farming in Denmark is provided by the studies of dairy farms carried out at the Danish Institute of Agricultural Sciences in the years 1989-1997 (Alrøe et al. 1998b). The studies are based on data recorded at 30-40 organic and conventional dairy farms, distributed over the whole country.

5.2.2 **Yields**

- is studies at dairy farms

A detailed analysis of crop yields at dairy farms was carried out for the years 1989 to 1993 (Halberg & Kristensen 1997), in which the expected yields for cereals, grass and beets were calculated using a model for the potential yield level. The crop rotation at the farms in question included, on average, 40% clover grass, which is in accordance with the crop rotation used in the organic scenarios. Winter cereals were grown on one fifth of the acreage used for cereals and, on average, 90 kg total-N in the form of manure was applied during the crop rotation.

which, adjusted for annual variations, give the present yield level

After adjustment for annual variations, the yields from the farms studied were found to accord with the available yield figures from the accounting statistics from organic farms in the harvest year 1996 (Danish Institute of Agricultural and Fisheries Economics, 1998). The other empirical data did not provide a basis for a different yield level, and the expected yields given in Halberg & Kristensen (1997), adjusted for the reference years 1993-96, are used in the organic scenarios as *present yield level* (table 5.4).

An improved yield level also included- because of greater focus on cereals

Besides the present yield level, which is primarily based on organic farms as they look today, the scenarios also include *an improved yield level* since there is good reason to assume a potential for a higher yield that is not fully expressed in the existing empirical data since present practice is dominated by farms focusing on milk production. With 100% organic farming, there would be considerably greater focus on growing feed grain. This is deemed to provide a basis for improved cereal cultivation practice and a higher yield in cereals, in line with the difference in conventional farming between dairy farms and pig and arable farms. There would be a possibility of an increased proportion of winter cereals, increased use of intercropping, improved fertilisation and sowing techniques and improved weed control. (Alrøe et al. 1998b)

- and, in the case of grass, because of a lower milk yield

In the case of clover grass, it is known from several studies in Denmark and elsewhere that, in grazing conditions, there is a close relationship between a pasture's net yield and the milk yield. The higher the milk yield, the lower the net yield in the pasture (Alrøe et al. 1998b). The average milk yield is 4 to 12% lower in the scenarios than in present organic practice and lowest in scenarios with improved yield level because of a lower percentage of bought-in protein feed (see section 5.3).

Table 5.4 *Expected yield in cereals, beets and grass for three different types of soil and at national level with present and improved practice* (Alrøe et al. 1998b)

	Clayey soil	*Irrigated sand*	*Unirri-gated sand*	*Present yield level*	*Improved yield level*
Cereals, grain (c.u../*ha*)	39	37	30	34	39
Fodder beets (cu./*ha*)	105	97	90	97	97
Clover grass (c.u../*ha*)	57	55	48	52	57
Distribution of types of soil (%)	*39*	*10*	*51*	*100*	*100*

One crop unit (cu) equals 100 feed units (FU)

Beets, peas and rape also grown

In the organic scenarios, peas are grown as well as cereals, beets and clover grass. The peas are assumed to be largely produced mixed with cereals and with the same yield level (*f.u./ha*) as cereals because the data on which the expected cereal yields are based include a considerable proportion of pulses (Alrøe et al. 1998b). Furthermore, rape is produced in the two scenarios without import of feed. Experience in growing organic rape is limited, but, here, a yield of 23 hkg/ha is assumed, as in Mikkelsen et al. 1998.

5.2.3 **Fertiliser**

Fertiliser distributed

As mentioned in the introduction, the number of animals and thus also fertiliser production vary in the various organic scenarios. The fertiliser produced is distributed according to a fertilisation plan corresponding to the empirical basis for the expected yields and fertilisation standards for organic farming. However, clover grass does not receive animal manure in the scenarios, thereby differing from the empirical basis. That could affect the clover grass's supply of potassium, but it is assumed here that the yields in clover grass can be maintained despite this difference. However, there is considerable uncertainty in the case of light soil, where potassium could cause problems in the cultivation of clover, and that in turn will cause problems with nitrogen fixation (see discussion of this in Færge & Magid 1998 and section 5.7).

- and the yield in cereals can be adjusted on the basis of the available quantity of fertiliser

Fertilisation in cereals varies in the scenarios, all depending on whether there is a shortfall or surplus of fertiliser in relation to the fertilisation plan. The cereal yields in the scenarios have therefore been adjusted in relation to the expected yields in table 5.4, with a yield response of 12 kg grain per kg total-N, based on Askegaard and Eriksen (1997). The relationship between fertiliser production and cereal yields is shown in table 5.5.

Table 5.5 *Fertiliser production and need for fertiliser (total-N) according to the fertilisation plan and expected fertilisation and yields in cereals in the organic scenarios* (Alrøe et al. 1998a)

	Present level of yield			*Improved level of yield*		
	0% import	15-25%	Unlimited	0% import	15-25%	Unlimited
N-need according to plan (*mill. kg*)	162	162	162	161	162	162
N in fertiliser ex store (*mill. kg*)	124	152	171	138	169	174
Fertilisation in cereals (*kg N/ha*)	60	92	107	74	105	109
Yield level in cereals (c.u*./ha*)	29	33	35	36	40	40

5.2.4 **Seed for drilling**

Seed-borne diseases cause problems

85-90% of all grain seed is dressed today, as is a large proportion of other crops in Denmark. If dressing were generally omitted, we would expect rapid proliferation of several of the most significant seed-borne diseases. The problem would be worst in cereals, and there could also be substantial losses in beets. Seed-borne diseases are deemed to be of less importance for peas and rape.

Today, research is in progress on several alternative methods of combating seed-borne diseases, including use of resistant varieties, use of biological products and mechanical methods. None of these methods has been fully developed and major R&D work must be done before we can assess whether or not these methods could replace the chemical products.

Continued seed dressing of the first generations of cereals, followed by a need assessment of subsequent consignments of seed would be one way of considerably reducing the use of fungicides (Danish Environmental Protection Agency 1999a).

- and must still be controlled
It is assumed in the scenarios that seed-borne diseases are controlled to the extent needed, using the organically most acceptable products.

5.3 Livestock production systems

Organic livestock farming differs in several ways from conventional livestock farming. Here, we will look at the relationship between feed consumption, production and production conditions in organic production systems. As mentioned in the introduction, in order to simplify the model, the present production of poultry is included as pork production in the organic scenarios.

Livestock farming assumed to be evenly distributed
Manure is a limited resource in the organic scenarios and is therefore assumed to be available where needed. Owing to the constraints of organic crop rotations (cf. section 5.2) and the limited possibility of transporting manure in a 100% organic Denmark, livestock farming must be assumed to be more evenly distributed over the country than it is today.

- in organic production systems
In conventional farming, livestock production systems vary greatly, from intensive housing systems with totally slatted floors to free-range sows and free-range hens. Organic livestock farming lies at one end of this spectrum, requiring outdoor areas for all animals. There are also special requirements concerning the composition of the feed, a higher weaning age for piglets, etc. It is also necessary to retain as much of the manure’s nutrients as possible in the construction of housing systems and the handling of fertiliser and during grazing.

- although there is only limited experience with pigs and hens
The relationship between feed, production systems and the production of animal products and fertiliser is described on the basis of the available data, which differ somewhat for the various forms of production. For example, there is only limited experience with organic pig farming and egg production, but considerable empirical data for assessing the relationship between feeding and production in organic milk production (Hermansen et al. 1998).

5.3.1 Production of organic milk and beef

Three feed plans are used for cows
- with different milk yields
In the organic scenarios, we operate with three different feed plans for cows, which result in three different milk yields. Two of the feed plans are without bought-in supplementary feed, one without and one with beets, and a feed plan that is optimised by buying in feed. The relationship between annual milk yield per cow (delivered ex farm), meat production and feed plans is shown in table 5.6. The optimised feed ration gives a milk yield of 6,500 kg energy-adjusted milk (EAM), which is close to the yield level seen in practice. The milk yield in the organic scenarios lies between 5,900 and 6,200 kg EAM in

scenarios with present yield level and between 5,700 and 6,000 kg EAM in scenarios with improved yield level, lowest in scenarios with smallest import (Alrøe et al. 1998a). In conventional dairy farming, feed and yield level are slightly higher than in “optimised” in table 5.6. At the same time, the proportion of pasture feed (Agricultural Advisory Service 1998) is somewhat lower in organic farming today. That means that the milk yield per cow in the organic scenarios is about 10-15% lower than in Danish farming today, and the proportion of pasture feed is considerably higher. Conversely, the number of dairy cows is 10-15% higher than today.

Table 5.6 *Feed consumption for cows (incl. 1.03 year cows and 1 bullock[a]) in three different feed plans, with annual milk yield per cow (ex farm) and meat production* (Alrøe et al. 1998a, based on Hermansen et al. 1998)

Feed plan	*Without supplementary feed*	*With beets*	*Optimised*
Grass and silage	6,975	5,996	5,604
Cereal	1,302	1,109	2,099
Beets	0	1,707	0
Rape cake	0	0	991
Straw	75	78	182
Feed, total (*f.u. per animal per year)*	8,352	8,890	8,876
Milk yield (*kg EAM*)	5,540	6,085	6,500
Meat, cast cows and heifers	241	241	241
Meat, bullocks	280	280	280
Meat production, total (*kg supplied weight)*	521	521	521

[a] Each of the two feed plans includes half of the bullocks in Hermansen et al. (1998).

The cattle are untethered
- and the male animals fattened as bullocks

The systems considered are based on untethered cows and rearing in open housing with straw litter in stalls in the winter period, when the manure is collected in the form of slurry, and grazing in the summer period. It is also assumed that the calf is fed with milk for a long period, including 1-2 days with the cow. A milk delivery to dairies of 92% is therefore assumed, so a considerable amount of milk can be used for the calves. It is assumed that the male animals are fattened as bullocks, grazing in the summer months and in open housing on straw in the winter months. This is very different from conventional production, which is today based mainly on intensive indoor fattening on a feed ration rich in concentrated feed (Agricultural Advisory Service 1998).

The health and welfare that can be achieved in the systems depend to a large extent on the individual production manager, but the assumed physical frames are basically regarded as suitable for achieving good health and welfare. In studies of organic dairy herds, Vaarst & Enevoldsen (1995) found a generally good state of health and that the organic rules for livestock farming provided a good framework for prevention and treatment of disease.

5.3.2 **Organic pig farming**

Organic pig production is just beginning

Today, only a few production results are available for organic pig farming. Results from running in organic production in some few herds are described by Lauritzen & Larsen (1998), but do not provide a sufficient basis for outlining the biological relationships in full-scale organic production. We have therefore chosen to estimate the possible relationships in organic pig production on the basis of results from conventional production, but adjusted for the conditions applying in organic production.

- and housing systems are being developed

Late weaning for piglets

The calculations are based on a production system with free-range sows and the weaned piglets and fatteners in housing with an outside area. Housing systems for organic pig farming are now being developed, and it is assumed in the scenarios that half the animals are on deep litter and half on straw flow. The piglets are weaned at seven weeks and 18.7 fatteners are produced per sow per year.

These production conditions are regarded as good for the animals' health and welfare compared with conventional production. The empirical basis for assessing the health and welfare conditions is extremely slender, but preliminary results from studies in progress indicate that the systems considered are appropriate with respect to the animals' health and welfare (Hermansen et al. 1998)

- and the pigs get coarse feed

Sows and fatteners can utilise considerable quantities of coarse feed, as shown in current studies. In the organic scenarios, the sows would receive about half the feed they need during gestation covered by grass and silage, and the fatteners would get 5% of the feed units via grass and silage. Daily growth of 750 grammes is assumed with a feed consumption of 3.0 f.u. per kg growth for fatteners slaughtered at 80 kg slaughtered weight. Table 5.7 gives key figures for feed consumption and production in organic pig farming in the organic scenarios (Hermansen et al. 1998)

- unlike conventional pig farming

In conventional, typically indoor, pig farming, the piglets are weaned at 4 weeks, annual production is 22.8 pigs per sow, the feed consumption per kg growth is lower and grass is not used (Agricultural Advisory Centre 1998).

Table 5.7 *Feed consumption and meat production for sows* (Alrøe et al. 1998a, based on Hermansen et al. 1998).

	Year sow with 18. 7 fatteners
Grass and silage	600
Cereals	3,971
Peas etc.	1,346
Rape/soy meal or similar[a]	382
Bone meal or similar	229
Feed, total (*f.u. per animal per year)*	6,528
Meat, cast sows	80
Meat, fatteners	1,496
Meat production, total (*kg slaughtered weight)*	1,576

[a] In scenarios without import, rape cake is used for the pigs; in scenarios with import, soy meal is used.

5.3.3 **Organic egg production**

There are organic egg production systems

Related values for feed consumption and production in organic poultry keeping have been determined over a 3-year period in four flocks by Kristensen (1998). The conditions for organisation of the production are also described. It is assumed that these results can represent the conditions in organic egg production in general. The relationships used in the organic scenarios are given in table 5.8.

Table 5.8 *Feed consumption and egg production for hens* (based on Hermansen et al. 1998)

	100 year hens
Feed, total[a] (*kg*)	5,200
Grain (%)	70
Peas etc. (%)	20
Soya beans etc. (%)[b]	5
Bone meal or similar (%)	5
Egg production (*kg*)	1,690

[a] Excl. 687 kg for pullet production

[b] In the scenarios without import, soya beans can be replaced by rapeseed. However, as some breeds of fowl do not tolerate rapeseed, a higher proportion of peas is used in the scenarios.

- but there are problems - with cannibalism for instance

In the housing systems on which the production results are based, the hens are kept in hen houses in flocks of 1,000-4,000 and with access to a hen run. It has been found that in some cases the hens make only limited use of the hen runs and that the mortality is often high, partly as a consequence of cannibalism.

These things are attributed to a combination of flock size, genetics and the "operation" of the hen run (access to it, protection in the run). The production systems considered cannot generally be said to be appropriate, but it is assumed that they can be developed into satisfactory systems from the point of view of animal welfare without that having an adverse effect on the given relationship between feed consumption and production (Hermansen et al. 1998). Studies now in progress also show that the tendency towards cannibalism is closely linked to certain breeds (Sørensen 1998).

5.4 Production of open-grown vegetables

Vegetables are high-value crops
- with specialised production
Vegetable production is characterised by very great diversity, which makes it difficult to generalise about possibilities and problems in connection with organic production. However, there are some common features. Vegetables are generally high-value crops and the quality of the product is critical. Conventional production is in many ways characterised by intensity and specialisation. Production per unit of area is usually high, with a big input of labour, machines, energy and ancillaries, and establishment costs can be high, both for the individual culture and for the production system. As a rule, specialised production management and manpower are required, together with specialised machinery for production, processing and storage. Sales conditions, climate and types of soil can also result in geographical concentration of production.

The intensive, specialised production and the high value of the products give rise to a slightly different problem in organic vegetable production than in ordinary agricultural operation because it can be difficult to take advantage of biological and ecological diversity through extensification and geographical spread. This conflict between ecology and specialisation is discussed below.

There is a considerable production today
There is already a considerable production of organic vegetables. 6% of the land used for growing vegetables was cultivated organically in 1994, and by 1997, the percentage had increased to 7-8%. However, the organic production consists mainly of just a few crops, with carrots and onions as the biggest productions. Most Danish vegetables are sold on the home market with the exception of peas for canning. The sale of organic vegetables depends on a change in the consumers' preferences and thus on a change in the perception of high quality vegetables. However, the traditional quality requirements will presumably continue to apply to a greater or lesser extent to organic products (Thorup-Kristensen & Sørensen 1998).
- because of a change in consumer preferences

There are generally serious problems with diseases and pests in vegetables – also due to the high quality requirements concerning the productions. Larger quantities of pesticides are thus used in conventional vegetable production than in ordinary arable farming, and the economic value of using pesticides is very high because of the high value of the crops.

5.4.1 Yields and economic aspects

The economics depend on a balance between inputs and yield
Despite the problems with pests, it is technologically possible today to produce some vegetables organically without any serious reduction in yield per hectare, while in the case of other vegetables, yields fall by 50% or more. Even so, there is a considerable organic production of some of the vegetables with a considerably lower yield per hectare. The economics of organic

vegetable production depend on a balance between the input – particularly in the form of seasonal labour for establishment, weeding, netting, etc. – and the price premium that can be obtained for organic vegetables (Thorup-Kristensen & Sørensen 1998).

- but the variation is also a problem

Besides a general reduction in yield and conventional quality compared with the input, cultivation without fertilisers and pesticides would mean a bigger variation in yield and quality. This could cause problems for the individual producer's economy to the extent that was still based on specialised and concentrated production. Big variations in the production could also cause problems at the retail level. However, there are several ways of solving these problems, as recommended in Action Plan II (Ministry of Food, Agriculture and Fisheries 1999).

Integration in the rotation

Geographical spread would contribute to a generally more stable organic vegetable production by giving diseases and pests poorer conditions for propagation. Greater integration in other agricultural crop rotations would have a number of advantages from a cultivation point of view, and growing more crops would make the individual producer's economy less dependent on variations in the yield. However, specialised productions still offer many economic advantages, even with organic production, and the type of soil, climate and possibilities for irrigation will continue to impose constraints on vegetable production.

5.4.2 **Nutrients**

- offer new opportunities

Vegetable production takes large quantities of nutrients out of the soil, and these must be returned in order to maintain a balance in the longer term (see section 5.7). At the same time, vegetable crops are more dependent on a high accessibility of nutrients in the soil than most other crops. In the organic scenarios, it is envisaged that vegetable production will be included in the rotation through increased cooperation between livestock farms and vegetable growers, with the possibilities for utilising crop rotations and manure implied by that. Despite that, it will be more difficult than it is today to obtain the necessary organic fertilisers in 100% organic farming, and that can cause serious problems for vegetable growers.

- but potassium is a problem

With respect to nitrogen, it is considered that, in practice, systems can be developed within a short span of years that ensure both a suitably supply of nitrogen to the crops and small losses to the environment. With respect to phosphorus and potassium, farmers and producers will be dependent on a supply from manure and other fertilisers. In the organic scenarios, the vegetables are fertilised with manure. Potassium present a serious problem because some crops take very large quantities of potassium from the soil. For example, carrots take more than 300 kg/ha and garden cabbage takes more than 200 kg/ha (Thorup-Kristensen & Sørensen 1998). It should be remembered, however, that only 0.3% of agricultural land under rotation is used for vegetable growing (see section 5.1).

5.4.3 **Seed for drilling**

A particularly important factor in the development of organic vegetable production is the requirement that organically grown seed be used. The production of outdoor vegetables is characterised by a large range of varieties within the individual cultures because the varieties have different characteristics with respect to cultivation and quality. In organic cultivation, too, there will be a need for a selection of suitable varieties with respect to cultivation security and quality. Cultivationally, it is very important to have varieties for early/late production, with tolerance to diseases and pests, good harvesting and preparation properties and sufficient storage and shelf life. Requirements concerning organically cultivated seed are expected to increase the price of seed considerably, and it is not certain that it will be possible to produce seed of the present quality, particularly with respect to seed-borne diseases. In the organic scenarios it is assumed that seed of satisfactory quality will be available.

5.4.4 **Perspectives for increased organic production**

The proportion cultivated organically varies greatly

It is difficult to assess the extent of yield variability, weed, diseases, pests and fertilisation problems in organic production. The degree of restructuring and thus the empirical basis for saying anything about 100% organic vegetable growing vary greatly between the different crops, from carrots, where more than 15% of the acreage is cultivated organically, to cauliflower and broccoli, where less than 1% is cultivated organically. This distribution of the organic cultivation of vegetables in practice does, however, in itself say a little about where the problems are greatest in organic cultivation. There is only a limited production of crops that are particularly characterised by yield variability, high establishment costs, big requirements concerning nitrogen supply and pests. Cauliflower, broccoli and Chinese cabbage, which suffer from all these factors, are largely not grown organically. There is, on the other hand a big organic production of, for example, carrots and onions despite the fact that weed problems are greatest in these crops. Similarly, very serious plant diseases, such as onion mildew and potato blight, do not prevent onions and potatoes from being grown organically. Although weeds and diseases are absolutely serious in organic vegetable growing, it seems that the growers are able to handle these problems in such a way as to achieve a reasonable economy in their production. For a few of those vegetables that are stored – particularly Chinese cabbage and onions – organic production will mean a shorter season for the vegetables because of storage problems.

- but production is still developing

The development that has taken place in the last few years gives grounds for some optimism. Many species of vegetable are grown with good results today and much succeeds that would have been almost impossible just a few years ago. It can be assumed that this development will continue and that even more vegetable crops will be successfully grown organically in the years to come. The conclusion is therefore that one of the best means of promoting organic vegetable growing is to support the development of new cultivation methods and strategies.

5.5 Production of fruit and berries

Fruit and berries are a very intensive and specialised form of production
Fruit and berries are produced in permanent cultures with a lifetime of 3 to 20 years and establishment costs up to DKK 100,000 per hectare. There are some similarities with vegetable production in that fruit and berry production is usually very intensive and specialised and requires a lot of manpower. There are serious problems with pests and diseases and very high treatment frequencies with pesticides. Overall, self-sufficiency in fruit and vegetables in Denmark today stands at 50%.

At the beginning of the 1990s, the organic acreage under fruit and berries was rather constant – around 2% of the total acreage used for this purpose. In the last few years, the acreage has approximately doubled. The increase in acreage has been greatest in the case of blackcurrants, presumably because of particularly favourable price relations, combined with the poor economic viability of conventional blackcurrant growing (Lindhard & Daugaard 1998).

and quality is an important parameter
As in the case of vegetable production quality is a very important parameter in the production of fruit and berries for consumption. It may be difficult to maintain the conventional quality, based on size and appearance, in organic production. There are also serious problems in living up to the storage and shelf life that can be achieved with conventional production, where fungal diseases can be kept in check with pesticides.

5.5.1 Yields

There is a big fall in yield
- particularly due to
Unlike the yield per hectare on organically grown vegetables, the yield per hectare on all kinds of fruit and berries grown organically is considerable lower than the yield on conventionally grown fruit and berries. The empirical basis for assessing the yields with organic production is rather slender. With the existing varieties, average yields with organic production have been found to have fallen by 40-85% for the various varieties, but there are big variations. The yield also depends on whether organically approved spray products are used and depends greatly on the variety. Table 5.9 shows the level of yield with already established varieties of berries and some serious problems in organic production of selected types of fruit and berries. Fungal and viral diseases are the main causes of problems with yield and quality, whereas weeds are only a serious problem in blackcurrants.

Table 5.9 *Some problems in organic production of selected types of fruit and berries, and the proportion grown organically in 1997* (Lindhard & Daugaard 1998).

Types	*Apples*	*Pears*	*Sour cherries*	*Blackcurrants*	*Strawberries*
Proportion grown organically	3-4%	3-4%	Approx. 0.5%	4-5%	2.5%
Establishment cost	100,000	100,000	12,000	15,000	35,000
Main problems	Apple scab, apple sawfly, various leaf rollers	Pear scab, pear gall midge	Grey monilia, cherry leaf spot	Blackcurrant bud gall midge, fungal diseases	Grey mould
Weeds	minor problem	minor problem	minor problem	major problem	minor problem
Reduction in yield	50-100%	50-65%	?	56%	38-48%
Variation in yield	great	great	great	great	great

5.5.2 **Handling of pests and pathogens**

- fungal diseases

Fungal diseases can be avoided to some extent through choice of varieties and breeding for resistance, but there can be problems with the taste, storage and shelf life and consumer preferences. There are a number of more or less resistant varieties, both new and old, on the market today, but only limited data are available on the yields in resistant varieties grown organically or unsprayed. Some of these varieties are also rather sensitive to pests.

In a trial with 10 different scab-resistant varieties of apple planted in 1994, the first real yield came in 1997. In that year, the trees yielded an average of 11.6 tonnes per ha. Quite a few of the fruit had scab, indicating that the scab resistance is not absolute or is being degraded. 25% of the fruit had been attacked by pests. Breeding woody cultures takes a long time and it is therefore more difficult to produced new, resistant varieties of fruit and berries than of other crops, and there may also be a problem in keeping up with the degradation of resistance. The long culture time and big establishment costs are other obstacles to introducing new varieties in practice. In this connection, strawberries are more like vegetables (Lindhard & Daugaard 1998).

Under the present Danish rules, sulphur may be used as spray product in organic fruit and berries, while the EU rules also allow spraying with copper. Copper must not be used in organic cultivation in Denmark. Sulphur is less effective against scab and has an undesirable effect on useful animals in the orchard. Fungal diseases cannot be combated only by cultivation methods, but the level of the diseases can be reduced by keeping the trees small and open and removing fallen leaves or digging them down.

Not much research is going on within organic methods of preventing pests in organic fruit growing in Denmark, but methods developed within integrated production could perhaps be used in organic production units. The use of pesticides that are gentle on useful animals has thus largely eliminated the problem of spider mites in apples.

5.5.3 **Apples and pears**

The problems are biggest in apples

Studies of the present production of organic apples show a very low level of yield compared with conventional production. For pears, the reduction is not quite as big. The problems are not due to fertilisation or weeds. These problems can be countered with the existing methods with use of extra manpower and continued development of the methods. The biggest problem is fungal diseases. The only way to handle fungal diseases is to breed resistant varieties.

In other countries, organic production of pomes goes much better than in Denmark. One of the reasons for this is that producers in almost all other countries are allowed to use copper in the production. Countries with a drier climate than Denmark – for example, Argentina and some states in the USA, do not have serious problems with apple scab. That gives these countries a major competitive advantage (Lindhard & Daugaard 1998).

5.5.4 **Berries**

- and less serious in berries

There is at present very little production of sour cherries. That may be due to technical problems in supplying sufficient nitrogen, problems with fungi and appropriate weed control. More research in this area could presumably solve these problems. On the face of it, it should be easier to switch to organic production than in the case of pomes because the fruit goes to industrial processors and therefore does not have to meet the same high quality requirements as fruit for direct consumption.

The biggest problem in blackcurrant production is general attack by the viral disease reversion, which is transmitted by blackcurrant bud gall mites. Breeders in Scotland are at present working towards resistant varieties with a usable quality of juice. The biggest technical problems in blackcurrant production are the supply of sufficient nitrogen and effective weed control. These problems are now being studied in a research project at Årslev Research Centre. However, as long as producers can charge a 300 per cent higher price than the traditional prices, they will continue to find organic blackcurrant production a paying proposition. This can be seen from the relatively large number of newcomers to blackcurrant production.

The acreage used for organic production of strawberries is relatively small even though there are no major technical problems. Methods for organic production have been developed and there are also resistant varieties. However, many growers may not yet be aware of that. In addition, the varieties that are resistant to pests and pathogens and that are suitable for organic production, are not suitable for retail sale because they have a relatively short shelf life. Organically grown strawberries must therefore be sold quickly and preferably locally (Lindhard & Daugaard 1998).

5.6 **Forestry**

It is difficult to use and transfer the rules for organic production of agricultural and horticultural products to the forestry sector because the time horizon and the production period within forestry are very long – from about 10 to 150 years – with continuous value growth throughout the production period. We shall therefore focus in the following on the consequences of the fact that artificial fertilisers and pesticides must not be used in organic production.

5.6.1 **Timber production**

Only minor changes in established forests

In most cultivation systems for timber production, neither artificial fertiliser nor manure is used. Large quantities of nutrients are not removed during harvesting, and it is therefore rare today to supply nutrients from outside. They may be supplied to improve vitality and health, particularly in types of soil in Central and West Jutland, which is short of nutrients. In some cases, artificial fertiliser is used for some years before cutting because supplying nutrients can be financially beneficial.

- and in connection with afforestation

The situation is approximately the same in the case of afforestation. Before planting, the land will normally have been used for ordinary farming, and the soil will therefore contain sufficient nutrients for the new plants to establish themselves and grow well. In the course of some years, conditions become as in ordinary forestry, where – as mentioned above, fertiliser is not normally used.

- but problems with national monuments in old forest areas.

There is very little need for plant protection in forestry compared with other agricultural sectors. Prohibiting the use of pesticides would particularly give rise to problems with national monuments in old forest areas. Owing to the nature of the land, there is usually little possibility of mechanical weed control. In addition, pests can cause serious problems. After some years' growth, the culture is able to cope on its own, and pesticides are not used in the following 50-150 years. The phasing out of the use of pesticides would mean a considerably longer culture phase, incomplete cultures and increased costs for replanting, resulting in poorer economy and a different composition of forests. Unlike replanting in forests, afforestation offers good possibilities of mechanical prevention and control of weeds (Østergård 1998).

5.6.2 **Ornamental greenery**

Ornamental greenery needs nutrients

The acreage used for Christmas trees (Norman fir) totals about 21,000 ha, whereas ornamental greenery covers about 17,000 ha (Østergård 1998). In the production of ornamental greenery and Christmas trees, unlike timber production, large quantities of nutrients are removed in the harvest phase. It is therefore necessary to supply nutrients to the soil in this type of production. Nowadays, the nutrients are supplied via fertilisation. However, it is quite common not to fertilise for the first 3-4 years after planting and then to use a mixed fertiliser every year. Trials have been carried out with manure, but manure is not widely used, and the technical problems of getting it to where it is needed and applying it, together with odour problems, have not been solved.

- and stopping using pesticides would have serious consequences

Greater use is made of pesticides in the production of ornamental greenery than in other forms of forestry. Owing to the market's high quality requirements, a total ban on the use of pesticides in the next few years is expected to ruin the production of ornamental greenery. In the longer term, cultivation methods might be developed that would enable producers to do without herbicides, but insect attack would still be a very serious threat to the financial viability of the production. A detailed discussion of the consequences is given in Østergård (1998).

In 1996, Christmas trees were grown organically on 145 ha land, and action is now being taken to encourage the production of organic ornamental greenery (Ministry of Food, Agriculture and Fisheries 1998). However, in view of the foregoing it can be concluded that it will be difficult to get a larger organic production of Christmas trees and ornamental greenery going, and extensive development work is needed.

5.7 Nutrient balances

This section contains a discussion of 100% organic farming from an agronomic angle. The environmental aspects are discussed in section 6.1.

The nutrient balances
Table 5.10 shows the overall balance with respect to nitrogen (N), phosphorus (P) and potassium (K) in Danish agriculture in 1995/96 and in the organic scenarios as described at the beginning of this chapter. The nutrient balance is given partly as the total surplus and partly as the average surplus distributed over all agricultural land. The balance is calculated on the basis of the total supplies to agriculture in the form of fertiliser, bought-in feed, return products and waste from the rest of society and atmospheric deposition, and the total losses in the form of vegetable and animal products. The content of nutrients is assumed to be the same in conventional and organic products. Particularly in the case of nitrogen, an estimate is included for fixation in the soil as a supply to agriculture in the balances.

In the following tables, sludge and waste are only included in the nutrient balances for present production and *not* in the balances for the organic scenarios because the current rules for organic farming do not permit the use of wastewater sludge. However, both today and in the longer term, there is a possibility of organically acceptable recirculation of nutrients from urban communities to agricultural land. The potential for recirculation is discussed in detail at the end of this chapter.

Table 5.10 *National balances for nutrients to and from agriculture per year in 1995/96 and in the organic scenarios, total and per ha of the total agricultural acreage* (Grant 1998)

		Danish agriculture 1995/96	*Organic scenarios*					
			Present level of yield			*Improved level of yield*		
			0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Total	N (*mill. kg*)	418	146	209	245	167	229	238
	P (*mill. kg*)	38	-4	12	23	-2	16	19
	K (*mill. kg*)		-10	8	20	-10	10	13
Per ha	N (*kg/ha*)	154	54	77	91	62	84	88
	P (*kg/ha*)	14	-2	4	9	-1	6	7
	K (*kg/ha*))		-4	3	7	-4	4	5

- express changes in the soil pool and losses
The national balance for agriculture expresses a total figure for changes in the soil pool and losses to water and the atmosphere. Within this total figure there can be dynamic relationships that are not expressed in the balance. In

the long term, the balance of nutrients should be positive in order to maintain the yields. The nutrient balances and the relationships that are not included in the national balance are described in greater detail below.

The agronomic problems of supplying crops with nutrients cannot be treated in detail here. It should, however, be mentioned that there is a dynamic balance in the soil between nutrients in an accessible form for plants and an inaccessible form, with the balance and the rate at which the substances can be made accessible depending on many factors, including both the ability of different types of soil to release the substances and the ability of different species and varieties of plant to utilise nutrients in the soil. Furthermore, the time the substances are accessible and the balance between the nutrients are of vital importance to the crops' growth.

5.7.1 **Nitrogen**

In the nitrogen balances,
- feed, fertiliser and fixation are important sources

Table 5.11 gives more detailed figures for the nitrogen balance in Danish agriculture in 1995/96 as it is expected to be after full implementation of Aquatic Environment Plan II (AEP II) and in the organic scenarios, where the estimates used for atmospheric deposition and fixation are given. Nitrogen fixation is the biggest contributor of nitrogen in the organic scenarios, while fertiliser and feed are the main sources in present production.

Table 5.11 *Nitrogen balances for agriculture (mill. kg per year)* (Grant 1998)

	Danish Agricu-ture 1995/96	*AEP II*	*Organic scenarios*					
			Present level of yield			*Improved level of yield*		
			0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Feed etc.	205	179	6	94	148	18	109	122
Fertiliser	285	177	0	0	0	0	0	0
Sludge, waste	9	9	0	0	0	0	0	0
Atmosph. dep.[a]	57	57	57	57	57	57	57	57
Fixation	30	31	159[b]	159[b]	159[b]	177[b]	177[b]	177[b]
N supplied	*586*	*452*	*222*	*310*	*364*	*253*	*343*	*357*
Plant prod.	63	42	19	19	19	19	19	19
Livestock prod.	105	105	58	82	100	66	96	100
N lost	*168*	*147*	*76*	*100*	*118*	*85*	*114*	*119*
N balance	*418*	*305*	*146*	*209*	*245*	*167*	*229*	*238*
Ammonia lost[c]	76	69	45	57	67	50	65	67
N to soil, net	*342*	*236*	*101*	*152*	*178*	*117*	*164*	*171*

[a] The same deposition is assumed in all scenarios, since account is not taken of the consequences of changed ammonia evaporation as a result of changed livestock production.
[b] There is an estimated uncertainty on the estimate for fixation of 56 mill. kg, see the text as well.
[c] Calculated on the basis of estimates for N from livestock, estimates for ammonia loss and loss through denitification in livestock housing and stores, during placing and grazing. These losses depend on, inter al. the housing system (see section 5.3). Evaporation from crops, which is assumed to be the same in all scenarios (11 mill. kg), is also included, and in 1995/96 and the AEP II scenario, evaporation from fertiliser (7 mill. kg) and ammonia treatment of straw is included (4 mill. kg).

It is difficult to estimate the nitrogen fixation

The overall nitrogen balance for the agricultural sector is based on more or less reliable estimates for added and lost nitrogen. It is important to note that the nitrogen fixation, which plays a big role, particularly in the organic scenarios, is difficult to estimate because it is difficult to separate it from the other elements in the nitrogen turnover in the soil. Furthermore, there is a relationship between loss to the atmosphere and the supply of nitrogen as atmospheric deposition. Here, we assume the same deposition in all scenarios because account has not been taken of the consequences of a change in ammonia evaporation as a result of livestock production.

- an empirical model is used
The nitrogen fixation has been calculated on the basis of an empirical model in which harvested dry leguminous plant matter, the nitrogen concentration, the percentage of fixated nitrogen in the harvested solids and the percentage of fixated nitrogen in the parts of the leguminous plants that are not harvested are included as parameters (Høgh-Jensen et al 1998). The model is used for both peas and clover. The peas contribute 17-24 mill. kg N per year in the organic scenarios, while clover grass, including underseed, contributes 142-153 mill. kg (Grant 1998). Since clover contributes most of the nitrogen fixation, the model assumptions concerning clover will be discussed in greater detail.

On the basis of Høgh-Jensen et al. (1998) and Hansen & Kristensen (1998), it is assumed that the fixation amounts to 56 kg N per tonne harvested clover (clover grass 1-2 years: 50% grazed white clover, 25% cut white clover, 25% cut red clover). It is also assumed that the total clover yield from the 2-year clover fields from sowing to reploughing is 5.0 tonnes/ha with present practice and 5.5 tonnes/ha with improved practice, corresponding to the solids yield in clover grass with 1.2 kg solids per f.u.

- but the factors are encumbered with great uncertainty
The fixation thus depends on a wide range of factors, each of which is encumbered with great uncertainty in the organic scenarios. However, it should be noted that there is a close relationship between the fixation and the level of yield. A significant deviation from the estimate shown in table 5.11 should therefore be reflected in a corresponding change in the level of yield, which will in turn affect the need for bought-in feed. If it is assumed that the proportion of clover in clover grass is changed by +/-15% units (from 25%-55%), that corresponds to changing the nitrogen fixation by DKK +/-56 mill. or +/- 21 kg per ha.

The nitrogen balance in the organic scenarios corresponds to Danish agriculture in the 1950s
It will be seen from table 5.11 that there are considerable differences in the nitrogen turnover and balance between the different scenarios. The nitrogen balance is highest in Danish agriculture 1995/96 (418 mill. kg), somewhat lower in AEP II (305 mill. kg), and lowest in the organic scenarios (146-245 mill. kg). Kyllingsbæk (1995) made some similar calculations for Danish agriculture in the period 1950-94. He found that, at the beginning of the 1950s, there was a total supply of 294 mill. kg. and that the nitrogen balance was 213 mill. kg. This corresponds to the turnover in the 15-25% scenario with the present level of yield.

According to Kyllingsbæk, the nitrogen balance at the beginning of the 1990s was 490 mill. kg. The nitrogen balance for Danish agriculture has thus decreased considerably in the last few years (see table 5.11), due mainly to falling consumption of fertiliser.

Balance - loss =nitrogen to the soil
On the basis of the nitrogen balance and estimates for losses to the atmosphere from fertiliser and crops, it is possible to calculate the net amount of nitrogen supplied to the soil (table 5.11). The losses occur in the form of ammonia evaporation and denitification from manure and ammonia evaporation from crops, fertiliser and ammonia treatment of straw, although the last two sources do not apply in the organic scenarios. In the soil, nitrogen enters into a complex, dynamic relationship in which particularly changes in the soil's pool of organic matter and the interaction between the accessibility of nitrogen in the soil and the crops' growth play a major role. The loss of nitrogen from the soil can be in the form of denitrification and leaching. A detailed discussion of potential losses and their environmental consequences is given in section 6.1.

Balance is assumed for phosphorus and potassium
In the organic scenarios, account is taken of the nitrogen available in the form of manure, fixation and atmospheric deposition, and the levels of yields therefore correspond to the nitrogen balances for the scenarios. The levels of yield in the scenarios are also based on the assumption that plant production does not fall in the long term due to negative nutrient balances for phosphorus and potassium. The yields are thus not adjusted on the basis of differences in the supply of these nutrients because it is assumed that there must be balance in the organic scenarios. These assumptions are discussed further below.

5.7.2 **Phosphorus**

The content of phosphorus in the soil is generally high - and the losses are small
Danish agricultural land has been supplied with a surplus of phosphorus for most of the last 100 years, thereby increasing its content of phosphorus. The phosphorus content in the root zone is in many cases 3-5 tonnes/ha. The content of easily accessible phosphorus is generally high in all regions of the country, with a phosphorus number (Pt) below 2 in only 5-10% of Danish soils. Measurements show that only negligible amounts of phosphorus are lost to the aquatic environment – on average, around 0.35 kg/ha per year. That corresponds to just under 1 mill. kg potassium lost from agricultural land per year – a figure that can be compared with the figures in table 5.12 (Færge & Magid 1998, Grant 1998).

Feed phosphates are the main source
In the organic scenarios, the supply of phosphorus to agricultural land largely consists only of feed (table 5.12), a substantial proportion of which is feed phosphates. In the 0-import scenarios, feed phosphates make up most of the supply. The national balance shows a surplus of phosphorus in the scenarios in which feed is imported and a small deficit in the 0-import scenarios. Since 1996, the phosphorus standards have been reduced, which is expected to lead to a reduction of about 3 mill. kg in the use of phosphorus in feed. Account has been taken of this reduction in the organic scenarios (Grant 1998).

Table 5.12 *Phosphorus balances for agriculture (mill. kg per year)* (Grant 1998, Kyllingsbæk personal communication)

	Danish Agriculture1995/96	*Organic scenarios*					
		Present level of yield			*Improved level of yield*		
		0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Feed etc.	47.9	12.4	32.8	47.9	15.9	39.6	43.3
Fertiliser	20.5	0	0	0	0	0	0
Sludge, waste	5.0	0	0	0	0	0	0
Atmosph. dep.	0.3	0.3	0.3	0.3	0.3	0.3	0.3
P supplied	*74.6*	*12.7*	*33.1*	*48.2*	*16.2*	*39.8*	*43.6*
Plant prod.	13.4	4.9	4.9	4.7	4.9	4.7	4.7
Livestock prod.	21.1	11.8	16.6	20.3	13.6	19.5	20.4
Loss of P	*34.5*	*16.6*	*21.5*	*25.0*	*18.5*	*24.2*	*25.1*
P balance	*40.1*	*-4.0*	*11.5*	*23.2*	*-2.3*	*15.6*	*18.5*

- and the need for phosphorus can be handled

Phosphorus is not generally expected to be a yield-limiting factor within a 30-50-year time horizon because of large reserves of phosphorus in the soil. Phosphorus will have to be supplied to soils with a low phosphorus number in the form of raw phosphate or through recirculation. Raw phosphate is a limited resource, and adding it would involve a risk of undesirable substances being supplied. Today, 5.7 mill. kg of phosphorus is recirculated in the form of sludge and waste, and this potential is not taken into account in the balances for the organic scenarios in table 5.12 (see also section 5.7.5 on recirculation). Distributed over the 5-10% of the land with low phosphorus numbers, this potential corresponds to a supply of 20-40 kg P/ha per year.

5.7.3 **Potassium**

Low content of potassium in sandy soil
- due to leaching

The content of potassium in Danish soil varies considerably with the mineralogy, weathering and leaching. For most of the last 100 years, Danish agricultural land has received a surplus of potassium, which has increased the soil's content of easily accessible potassium. In many sandy soils, however, the content of easily accessible potassium is low, despite a plentiful supply of manure. The reason for the low content is probably leaching. 50% of soils in West Jutland thus have a potassium number (Kt) of less than 8 (Færge & Magid 1998).

For the expected yields to be maintained

The nutrient balances for potassium (table 5.13) show a small deficit to a moderate surplus in the organic scenarios. There is then some loss in the form of leaching (see below). As mentioned earlier, in the longer term, a deficit on the nutrient balances in the soil should be countered by adding potassium. The effect of leaching on the nutrient balances is dealt with at the end of this section, but first we must determine whether the assumptions for the organic scenarios warrant a supply of potassium. It is thus assumed in the scenarios that differences with respect to potassium between the empirical basis and the organic scenarios do not give cause to change the expected yields (cf. section 5.2).

At the organic dairy farms included in the empirical basis for the yields in the organic scenarios, manure corresponding to 66 kg K/ha per year is allocated to clover grass and lucerne in rotation (Kristensen & Halberg 1995), whereas the clover grass fields in the scenarios do not receive manure. In the organic scenarios it is assumed, with the focus on nitrogen, that this difference does not make it necessary to reduce the expected yields. It can rightly be discussed whether this assumption holds good when potassium is included. The potassium balance at dairy farms was 33 kg K/ha per year. Compared with the balances in the organic scenarios (tables 5.10 and 5.13), this gives a difference of 26-37 kg K/ha, which can be countered by a total supply of 60-100 mill. kg K per year nationally, with the biggest need in the 0-import scenarios. (See also Færge & Magid 1998.)
- potassium will have to be supplied

Table 5.13 *Potassium balances for the agricultural sector (mill. kg/year) without a supply of potassium fertiliser in the organic scenarios* (Grant 1998, Eriksen et al. 1995, Kyllingsbæk personal communication).

	Danish Agricu-ture 1995/96	*Organic scenarios*					
		Present level of yield			*Improved level of yield*		
		0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Feed etc.	62.5	4.1	24.1	37.4	4.8	27.3	30.6
Fertiliser	80.4	0	0	0	0	0	0
Sludge, waste	4.7	0	0	0	0	0	0
Atmosph. dep.	8.2	8.2	8.2	8.2	8.2	8.2	8.2
K supplied	*156.8*	*12.3*	*32.3*	*45.6*	*13.0*	*35.5*	*38.8*
Plant prod.	48.5	9.8	9.8	9.8	9.8	9.8	9.8
Livestock prod.	14.2	12.0	14.2	15.9	12.8	15.5	15.9
K lost	*62.7*	*22.0*	*24.1*	*25.6*	*22.8*	*25.3*	*25.7*
K balance	*94.1*	*-9.7*	*8.1*	*19.9*	*-9.8*	*10.2*	*13.1*

Potassium leaches in soils lacking in clay
The effect of leaching of potassium on the potassium balance in the soil has also been investigated. In the soil, potassium reacts with the soil's clay minerals, and in soils with some content of clay, high concentrations of potassium will therefore become fixated in the soil. In sandy and peaty soil with a low content of clay, on the other hand, surplus potassium must be expected to result in leaching. The leaching of potassium from well fertilised soils in present practice is estimated to be 5-30 kg K/ha per year in different types of soil with different clay contents (Eriksen et al. 1995), which gives a weighted national average of about 20 kg/ha per year. That corresponds to total leaching from the entire acreage of the order of 50 mill. kg K per year, and thus, in extension of the balances in table 5.13, a total deficit of 30-60 mill. kg. on the potassium balance.
- and a deficit is expected on the balances

Leaching can perhaps be limited
The large pool of potassium in clayey soils means that some potassium deficit can be tolerated, even on a very long-term basis, if sufficient potassium can be released from the more strongly bound fractions to make up the deficit. However, a potassium deficit cannot be tolerated in coarse, sandy soil. The

leaching depends not only on the type of soil but also on fertilisation practice and crop rotation. Ongoing studies in an organic cultivation system with potassium balance on good sandy soil thus shows very limited leaching of potassium (Askegaard et al. 1999).

A supply of the order of 60-100 mill. kg would thus more than make up for the total deficit on the potassium balance, including estimated leaching of 20 kg K/ha/year, so the yields could be maintained in the long term.

5.7.4 **Sulphur**

Sulphur unlikely to be a problem
Owing to decreasing atmospheric deposition, there may be reason to look at the balance of sulphur as well. From a surplus of 6 kg S/ha per year in the 1970s, there was a deficit of 16 kg S/ha per year in 1989. However, there would be less need for sulphur in the organic scenarios because shortage of sulphur depends on the relationship between nitrogen and sulphur, and there is far less nitrogen circulating in the organic scenarios. However, fertiliser with sulphur in rape and a few types of vegetables may be necessary, particularly on sandy soil (Færge & Magid 1998).

5.7.5 **Recirculation of nutrients from urban societies**

Loss of nutrients must be made up for
Nutrients are lost from the agricultural sector in the form of plant and animal products through loss to air and water. To maintain the nutrient balance, it will be necessary in the longer term to make up for this loss. Nutrients can be supplied in the form of feed, mineral and organic fertiliser and, particularly in the case of nitrogen, biological fixation. The sources of nutrients are transfer from other ecosystems, including farming, extraction from soil, water and air and recirculation from the rest of society. In the following we take a look at the potential for recirculation of nutrients from urban communities.

Nutrients end up in waste
Today, many nutrients end up in various forms of waste, and the waste is collected and processed for many other purposes than recirculation of nutrients. The risk of supplying undesirable substances is therefore a considerable obstacle to recirculation of nutrients to agricultural land. Large amounts of potassium and sulphur end up in the aquatic environment because these nutrients, unlike phosphorus and nitrogen, are not deemed to constitute a problem for the environment.

- which is partially recirculated
The main sources for recirculation today are wastewater sludge, domestic waste and organic residuals from industry (table 5.14). Just under 70% of the total amount of wastewater sludge was supplied to farmland in 1996. This proportion has been falling since 1994 and is expected to continue falling for a variety of reasons, including stricter limit values for undesirable constituents. Less than 10% of compost and garden waste went to industrial agriculture in 1996 because these sources were primarily used in private gardens and public parks. More than 95% of the organic residuals from industry went back to farms as feed and fertiliser in 1996 (Eilersen et al. 1998).

Table 5.14 *Quantities of organic waste (mill. kg. per year) used as fertiliser in the agricultural sector in 1996* (Eilersen et al. 1998, Danish Environmental Protection Agency 1998a, 1998b)

Types	*To the agricultural sector*	*Solids*	*N*	*P*	*K*
Wastewater sludge	63%	162	7.1	5.1	0.5
Compost	Less than 10%	190	1.7	0.4	0.7
Garden waste		270	1.5	0.3	1.5
Industrial waste	93%	224	4.4	2.3	4.4

Sludge and waste are not included in the scenarios
- and there is an unutilised potential for recirculation
The total quantity of sludge and waste supplied to the agricultural sector in 1995/96 corresponds to 9.1 mill. kg N, 5.0 mill. kg P and 4.7 mill. kg K (Grant 1998). Under the current rules, wastewater sludge must not be used in organic production, and neither sludge nor waste is included in the organic scenarios. That means that there is a direct, unutilised potential for recirculation in the scenarios in the form of organic domestic waste and residuals from industry – and in the slightly longer term, human urine and fæces, which are today collected in wastewater sludge, are a possible source. However, the use of fæces in crops for human consumption should be avoided because of the risk of transmission of diseases. Separately collected human urine is of particular interest in organic farming as a high quality fertiliser for crops needing easily accessible nutrients, such as vegetables. Table 5.15 shows the potential sources for recirculation in the organic scenarios. Garden waste etc. is not included because, today, this is mainly used in private gardens and public parks.

In the organic scenarios, the potential quantities of waste from some of the agricultural sector's secondary industries must be assumed to fall as a consequence of falling production. From calculations of the quantity of organic waste from different types of industry (Andreasen et. al. in prep.), it is estimated that the quantity of solids would halve if the fall in production fed right through in the secondary industries. The quantity of phosphorus and nitrogen would presumably fall less because the two largest contributors, accounting for about half of the total quantity, are not affected by the restructuring (Danish Environmental Protection Agency 1998a). The quantity of nutrients from the different sources in 5.15 can be compared with the balances in tables 5.11 to 5.13.

Table 5.15 *Potential sources of recirculation of organic waste in a 100% organic agricultural sector (mill. kg per year)* (Eilersen et al. 1998, Andreasen et al in prep., Danish Environmental Protection Agency 1998a)

Types	*Solids*	*N*	*P*	*K*
Solid organic household waste	160	3	0.6	0.75
Human fæces	63	1.8	0.9	1.8
Human urine	110	20	2.7	4.5
Industrial waste	Approx. 100	over 1.9	over 1.6	?

5.8 Summary and conclusion

A total restructuring for organic agriculture in Denmark could generally be implemented, but at a lower level of production than today. However, the expected consequences for the agricultural sector would depend on the form of 100% organic production.

The time horizon of the scenarios is 30 years
To provide a basis for assessing the consequences of a total restructuring for organic production in Denmark, various scenarios have been set up for 100% organic agriculture with a time horizon of 30 years. This number of years has been chosen because of the extensive structural changes that would be needed. It is assumed that there would be an even distribution of manure and that the clover grass acreage would be used for grazing, which would in turn require a more even distribution of livestock production over the entire agricultural acreage. Extensive ”deregionalisation" of Danish livestock production is thus assumed in connection with the restructuring for organic production. In the financial analyses (chapter 7), it is similarly assumed that the return of livestock production to Eastern Denmark would take place as the surplus livestock housing capacity wore out. It is therefore assumed that there would be no costs in the form of “scrapping” of housing capacity in connection with the deregionalisation.

According to the current rules on organic farming, such farms must buy in conventional feed in quantities corresponding to 15-25% of the animals' daily feed intake (measured as the energy in the feed), and a certain percentage of conventional manure. In a 100% organic Denmark, there would be no conventional farms from which to purchase manure or feed, although it would be possible to import both organic and conventional feed. Three levels of feed import to Denmark are used:
- and there are three levels of feed import

- no import, complete self-sufficiency in feed
- 15% imported for ruminants and 25%, for non-ruminants
- unlimited import of feed and maintenance of the present level of livestock production (1996).

On the basis of the current rules, 15-25% of imports are assumed to be conventional feed and the remainder organic feed.

Vegetable for domestic consumption are produced in all the scenarios, but no vegetables are exported, in contrast to today's situation, in which the net export of grain accounts for almost one fifth of the harvest and there are significant exports of seeds, sugar and potato starch.

Milk and eggs as now
- while pork varies
In all scenarios, the production of milk and eggs corresponds to present production. The production of milk is limited by milk quotas and the production of beef is of the same size as today. The production of pork varies in proportion to the produced and imported quantities of feed (poultry is included in the scenarios as pork).

Besides the domestic consumption of animal products, exports of milk products and beef are at the same level as today, whereas exports of pork are unchanged with unlimited import and fall by nearly 40% with 15-25% import of feed and by more than 90% with 0-import.

A further three scenarios have been set up with a level of yield in cereals and clover grass that is 10-15% higher than the present level. In the scenarios with a better level of yield, pork exports fall by only 10% with 15-25% import of feed and by over 70% in the 0-import scenario.

Same production, but other production systems
Except for the export of plant products and pork and the production of special crops, production can be maintained unchanged in all the organic scenarios. However, this level of production is based on greatly changed production systems. Organic farming is based on diversified crop rotations with a considerable proportion of nitrogen-fixating and perennial crops. There is therefore 30-50% clover grass on all soils in the organic scenarios. Manure is a limited resource and is assumed to be evenly distributed from the standpoint of crop rotation. It must therefore be assumed that the livestock would be more evenly distributed in a 100% organic scenario than they are today. There are more dairy cows in the scenarios than in present-day agriculture, with a lower average yield, and bull calves from milk production would be fattened as bullocks. The cows would be kept in a parlour and yard system and put out to grass in the summertime. The sows would be out on grass and the bacon pigs would have access to an outdoor area and straw bedding.

The nitrogen cycle is reduced
The nitrogen cycle is significantly reduced in the organic scenarios, to a level corresponding to Danish agriculture in the 1950s, because nitrogen would not be imported in the form of artificial fertiliser. It would instead be obtained by symbiotic nitrogen fixation in clover grass fields and through importation of feed, but grain production would be limited by nitrogen in all the scenarios.

Necessary to import potassium
The scenarios indicate a number of constraints on a total switch to organic farming. The main constraint is probably that, in all scenarios, it is estimated that it will be necessary to import 60-100 mill. kg. of potassium per year (most in the 0-import scenarios) in order to maintain yields in clover grass at the level of the empirical basis for the scenarios. On coarse sandy soil, potassium leaches easily and has to be added.

- even though there is a potential for recirculation

There is an unexploited potential for recirculation of nutrients from urban communities in the organic scenarios. The quantities are relatively small compared with the need for potassium. Recirculation could, however, play a vital role, e.g. in vegetable production. Besides potassium, it would be necessary to import feed phosphates for the livestock, also in the 0-import scenario, to meet the animals' needs with the presumably relatively high level of production. That means, on the other hand, that there would be no problems with the nutrient balance for phosphorus.

Import of feed is important to the nutrient balance
To summarise, the loss of phosphorus and potassium through sales products would have to be made up for by a supply to farmland in the form of other mineral fertiliser, recirculation or feed. Nutrient import via feed thus plays an important role in the organic scenarios. As mentioned, present-day rules permit the use of 15% conventional feed for ruminants and 25% for pigs and poultry. However, an on going discussion within the EU indicates that permission to use conventional feed will be withdrawn over a period of years. In such case, the need for imported feed will have to be met with organically cultivated feed. If feed were supplied to a 100% organic agricultural sector in Denmark, there would be a corresponding loss from the agricultural sector elsewhere in the world, which would shift the nutrient problem but not solve it. It has not been clarified how the organic exporters of feed in other countries would achieve balance with respect to nutrients, so that a bigger organic import to Denmark could be maintained in the longer term. It is therefore uncertain whether it would be possible, in the long term, to maintain the present quantity of exported pork from a 100% organic agricultural sector in Denmark.

Particular problems in fruit, vegetables and special crops
Organic production of fruit, certain special crops and individual vegetable species is particularly problematical. In conventional production, larger quantities of pesticides are used in these crops than in ordinary farm crops, and the financial value of using pesticides is high. In apples, we would expect a catastrophic decline in yield – at any rate in the varieties used today – and there could also be difficulties with durability and, thus, with the length of the season. For vegetables, the increased yield variation would be a problem in itself, due to the high establishment costs and the accompanying economic risk. Lastly, with our present level of knowledge, it is not possible to produce organic seed of satisfactory quality because of the propagation of seed-borne fungal diseases. Continued seed dressing of the first generations of cereals, followed by a need assessment of subsequent consignments of seed would be one way of considerably reducing fungicide consumption.

It is difficult to use and transfer the rules for organic production of agricultural and horticultural products to the forestry sector because the time horizon and the production period within forestry are very long, with continuous value growth throughout the production period.

- and in ornamental greenery
Problems can be expected with national monuments in old forest areas, where there is little possibility of mechanical weed control, and it can be concluded that production of organic ornamental greenery on a large scale would be difficult and would require extensive development work.

6 Consequences for the environment and health

This chapter supplements the Bichel Report
This chapter describes the consequences for the environment and health of total restructuring for organic farming in Denmark. The consequences of a phase-out of pesticides are described in the report from the Sub-committee on Environment and Health. In continuation of that, importance is attached here to describing the consequences of the changed crop rotation and the phasing out of artificial fertilisation. This chapter should thus be seen as a supplement to the consequences described in the report from the Sub-committee on Environment and Health. The consequences for the working environment are not described, for example, because they are assumed to be the same as in the case of phasing out pesticides. The consequences of different livestock housing systems for the working environment in the organic scenarios (see section 5.3) are not described.

Sections 6.1 and 6.2, in which production-related pollution and energy consumption are discussed, are based directly on the organic scenarios described in chapter 5. The other sections – 6.3 on nature content, 6.4 on soil biology, 6.5 on consequences of constituents and 6.6 on veterinary drug consumption – are less closely related to the scenarios and are based on a number of Danish and international studies of organic farming and organic products.

6.1 Losses and pollution with nitrogen and phosphorus

Pollution with nutrients is assessed on the basis of the potential for losses

– taking AEP II into account
In this section, the pollution with nutrients in a 100% organic agricultural sector is assessed by describing the potential for loss of nitrogen and phosphorus in the organic scenarios as described in chapter 5. Danish agriculture as it was in 1995/96 is compared with how present agriculture is expected to be with full observance of Aquatic Environment Plan II (AEP II). In this last scenario, the livestock population is assumed to be as in 1995/96, while the growth of organic farming is assumed to continue, with an additional 210,000 hectares restructured in the period 1996-2003, besides the 45,000 hectares restructured in 1996. Other measures in the scenario are set-aside of wetlands and "particularly sensitive rural areas", afforestation, increased use of second crops, reduced use of the nitrogen standard and stricter requirements concerning use of feed and use of manure. It is estimated that these measures will together reduce the yield in all crops by more than 7%, or more than 1,200 million f.u. (Grant 1998). For comparison, the corresponding reduction in yields in the organic scenarios is 20-31%.

6.1.1 Nitrogen
Nitrogen lost

The overall nitrogen balance for the agricultural sector is based on estimates of supplied and removed nitrogen, as described and discussed in section 5.7. Loss of nitrogen to the atmosphere and the aquatic environment, which is not included in the overall balance, is described here. There is a risk of nitrogen loss in different places in the agricultural system's feed and nutrient cycle. The environmental impacts of nitrogen relate particularly to evaporation of ammonia and leaching, but denitrification in the soil and, secondarily, in the aquatic environment, can also result in emission of the greenhouse gas N_2O (see section 6.2).

- including through evaporation of ammonia
Balance – ammonia evaporation = net to soil.
The loss in the form of ammonia evaporating from manure depends on the production system and decreases with decreasing livestock production. However, in AEP II, better utilisation of feed is expected to reduce the amount of ammonia evaporating from manure. This change is not taken into account in the organic scenarios. There is also evaporation of ammonia from crops; this is assumed to be the same in all scenarios. 1995/96 and AEP II also include evaporation from artificial fertiliser and ammonia treatment of lye. The total balance for supply and loss of nitrogen in farming, minus the estimated loss in the form of evaporation of ammonia, gives a figure for the net supply of nitrogen to the soil (table 6.1). It should be noted, however, that the calculations are encumbered with great uncertainty, particularly concerning nitrogen fixation, as mentioned in section 5.7.1.

Net to soil = leaching + denitrifcation + changes in soil pool
All else being equal, the total balance for N to soil gives an indication of the potential for nitrogen leaching and denitification in the soil. This potential must be compared with the possibility of accumulation or release of organically bound nitrogen in the soil. Changes in the soil pool's content of N depend, at any rate in the short term, on cultivation practice. For example, a bigger proportion of perennial clover in the rotation has a beneficial effect on the soil's nitrogen pool, whereas frequent and intensive soil preparation has an adverse effect (Christensen & Johnston 1997). Readers are referred to Christensen et al. (1996) for a more detailed discussion of the effect of cultivation on the decomposition of organic matter in the soil in relation to organic farming.

However, with constant use of the same cultivation practice, it can be assumed that, *in the long term*, the soil's nitrogen pool will be constant because the mineralisation from the soil pool is assumed to be proportional to the size of the soil pool (Christensen & Johnston 1997). Thus, with constant cultivation practice, the size of the soil pool will gradually reach a point at which there is balance between supply and loss.

Relatively little denitrification
Denitrification is a process in which, in anoxic conditions, bacteria convert nitrate into gaseous nitrogen compounds. In connection with AEP II, denitrification in wet meadowland is used as a means of reducing nitrogen leaching to the aquatic environment. Reestablishment of 16,000 hectares of wet meadowland, where there is considerable denitrification, is expected to result in the removal of 5.6 million kg nitrogen (Iversen et al. 1998). With normal cultivation practice on land under rotation, denitrification depends in part on the type of soil and the water content of the soil. A clear relationship

with cultivation practice has not been established, but it is assumed that denitrification is associated particularly with the use of manure and that, in normal circumstances, the quantities lost are relatively small (Petersen 1996).

Net to soil is a potential for leaching
- which is reduced by 50-70%
Assuming equilibrium with the given cultivation practice in farming today and in the organic scenarios, so that the soil's nitrogen pool is constant, the reduction in the net supply of nitrogen to soil can be taken as a reduction of the potential for nitrogen leaching. It will be seen from table 6.1 that the net supply of nitrogen to the soil is reduced by 112 million kg under AEP II compared with Danish agriculture 1995/96, while the reduction is between 164 and 241 (+/-56) million kg per year in the six organic scenarios compared with Danish agriculture 1995/96. The interval indicates an uncertainty in the estimate for nitrogen fixation, which is the item associated with greatest uncertainty. For this reason, in the long term, a considerable reduction in leaching of nitrogen must be expected in the organic scenarios compared with Danish agriculture today. It should be noted, however, that the calculations are encumbered with great uncertainty.
- and a considerable reduction of leaching is expected.

Table 6.1 *Overall nitrogen balance for the agricultural sector (mill. kg per year), together with the net supply to the soil and the reduction of this compared with Danish agriculture 1995/96*

	Danish agricul-ture 1995/96	*APAE II*	*Organic scenarios*[a]					
			Present level of yield			*Improved level of yield*		
			0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
N-balance	418	305	146	209	245	167	229	238
Ammonia loss	76	69	45	57	67	50	65	67
N to soil *(mill. kg)*	342	236	101	152	178	117	164	171
Reduction in N to soil (*mill. kg*)	–	112[b]	241 +/-53[c]	190 +/-53	164 +/-53	225 +/-57	178 +/-57	171 +/-57
N to soil (kg/ha)	*126*	*87*	*37*	*56*	*65*	*43*	*60*	*63*

[a] The expected effects of AEP II are not included in the organic scenarios.
[b] Incl. reduction of 5.6 mill. kg as a consequence of increased denitrification
[c] This interval gives an uncertainty on the estimate for nitrogen fixation in clover grass (see section 5.7 for details)

Free-range sows can cause problems
Grazing is far more extensive in the organic scenarios than in present-day agriculture, and the fields would thus receive about three times as much manure as they do today. This would cause problems for the environment, particularly in connection with free-range sows, because sows like rooting in the soil and thereby break the grass cover. To reduce the risk of leaching of nutrients, it would be necessary to maintain close grass cover. Rooting could be reduced by ringing the sows. In organic farming, it is recommended that the sows be allowed to graze and that the use intensity be reduced in relation to the minimum area of 0.074 hectares per sow. This can be done by establishing buffer pens, pen rotation or grazing with other livestock. It is also recommended that the sows be supplied with greenfeed or other filling root material according to their appetite in periods with reduced grass growth (Larsen et al. 1998).

- and the potential for leaching is uncertain in the short term
With our present-day level of knowledge it is not possible to say anything clear about the potential for leaching in the short term as a consequence of the changed cultivation practice with a total switch to organic farming except that there would be a big incentive to take best possible care of the limited quantity of nitrogen. Assuming a yield response of 12 kg cereal per kg total N supplied (Askegaard and Eriksen, 1998) and DKK 1.5 per kg cereal, it can be calculated that the value of one kilo of nitrogen is DKK 18, which is 5-6 times higher than in conventional farming today. A detailed discussion of the potential for nitrogen leaching in the short term in connection with conversion to different types of organic farming is to be found in Kristensen & Olesen (1998).

6.1.2 **Phosphorus**

The environmental effects of phosphorous
- depend particularly on the phosphorus content of the soil
The phosphorus balance is less complex than the nitrogen balance because phosphorus is neither fixated from nor lost to the atmosphere. In modern agriculture, the undesirable environmental impacts of phosphorus are associated particularly with loss to the aquatic environment via soil erosion and transport of phosphorus down through the soil profile. These environmental impacts depend less on the supply in individual years than on the soil's total content of phosphorus.

When phosphorus is supplied to the soil with fertiliser or manure, the soluble part dissolves in the soil water, reacts with the soil's adsorption complex and consequently participates in an equilibrium process with the soil's less soluble forms of adsorption/precipitation of phosphorus. That means that phosphorus supplied with fertiliser/manure is immobilised. Phosphorus in the organic fraction of the fertiliser must undergo mineralisation before it can participate in the equilibrium process. Conversely, when crops absorb phosphorus from the soil water or if phosphorus leaches from the soil water, a reaction takes place from less soluble to more soluble forms, i.e. the phosphorus is mobilised. The crops normally absorb less than 10% of the fertiliser supplied in the individual year; the remainder comes from the soil pool.

The losses are small
- but can cause eutrophication
Loss of phosphorus to the aquatic environment through leaching usually accounts for only a small part of the net supply of phosphorus; the rest accumulates in the soil. Measurements carried out under AEP II's monitoring programme thus show average transports of 0.35 kg P/hectare/year in watercourses from farming-dominated catchment areas for the period 1989/95, which corresponds to a loss of just under 1 mill. kg P per year from the entire agricultural area. These figures can be compared with the balances in table 6.2. Although the loss of phosphorus to watercourses is of less agronomic importance, it is so high that it can cause eutrophication in shallow lakes and fiords.

When the soil's phosphorus content rises far above the agronomically optimum level, presumably at Pt of around 6, the risk of leaching of P increases drastically. Approx. 15% of Danish farmland has Pt above 6.0 (Grant 1998). The phosphorus balance in the organic scenarios is generally lower than in Danish agriculture 1995/96, even allowing for the lower feed standards since 1996 (section 6.2). In the longer term, a negative phosphorus balance in land with a very high phosphorus content can reduce the content of phosphorus and thus also the risk of leaching.

Table 6.2 *Phosphorus balances for agriculture, nationally and as an average per hectare agricultural land, per year* (Grant 1998)

	Danish agriculture 1995/96[a]	*Organic scenarios*					
		Present level of yield			*Improved level of yield*		
		0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
P-balance (*mill. kg)*	36.8	-4.0	11.5	23.2	-2.3	15.6	18.5
P-balance (kg/ha)	*13.5*	*-1.5*	*4.2*	*8.5*	*-0.9*	*5.7*	*6.8*

[a] Reduced by 3.3 mill. kg in accordance with changed feed standards for phosphorus for cattle since 1996.

The mobility of phosphorus also depends on the form of fertiliser and on the cultivation in practice. For example, in English soils, Johnston (1998) found that the mobility was greater when the fertiliser was supplied as organic fertiliser than when it was in the form of artificial fertiliser and that phosphorus was transported deeper into the soil under permanent grass than in rotation. This indicates that the mobility of phosphorus increases in the presence of fresh organic matter from supplied natural fertiliser or metabolism under permanent grass. However, there are no research results that provide a quantitative description of the risk of loss of phosphorus as a consequence of changed cultivation practice (Grant 1998).

6.2 Consumption of fossil energy and production of greenhouse gases

Consumption of fossil energy results in emission of the greenhouse gas CO_2

In this section we assess the consequences of a 100% switch to organic farming for agriculture's consumption of fossil energy – both direct consumption in Danish agriculture and indirect consumption in the production of fertilisers etc. – and for greenhouse gas emissions. Besides "classic" pollution with sulphur, nitrogen compounds, etc., the environmental consequences of fossil energy consumption are increased emission of carbon dioxide (CO_2), which acts directly as a greenhouse gas in the atmosphere. Other important greenhouse gases that are closely associated with biological processes in agriculture are methane (CH_4) and nitrous oxide (N_2O). More qualitatively, we will discuss the effects of changes in land use and livestock population on the emission of methane and nitrous oxide. Measured in terms of direct energy consumption per krone of turnover, the agricultural sector is the second-most energy-intensive industry. The most energy-intensive is the transport sector. In all, agriculture contributes around one tenth of Denmark's total contribution to the man-made increase in the greenhouse effect (Dalgaard et al., 1998).

6.2.1 Consumption of fossil energy

The consumption is the sum of the direct and indirect consumption

The agricultural sector's consumption of fossil fuel is calculated as the sum of the energy consumption for production of crops and animal products, and the energy consumption for the individual crops and products is the sum of the direct consumption of fuels and electricity and the indirect energy consumption via artificial fertiliser, machines, buildings and imported feed.

The direct energy consumption can be calculated and estimated with great certainty, but it is more difficult to calculate the indirect consumption. The cost of energy via imported feed, which is a big item, both in present-day agriculture and in the organic scenarios with imports, thus depends on the type of crop, the cultivation method, etc. We have chosen to use one and the same energy cost for all imported feed (Dalgaard et al. 1998). For present-day agriculture, energy for production of artificial fertiliser accounts for a significant part of the indirect energy consumption.

Net energy consumption = energy for plant production + energy for livestock production – energy production from biofuels

Table 6.3 shows the total net energy consumption in present-day agriculture and in the organic scenarios, compared with the size of the plant and livestock production. The total energy consumption is the sum of the energy consumption for crop production plus the extra energy consumption for livestock production, less the direct energy production from burning of straw and biogas.

Table 6.3 *Agriculture's consumption of fossil energy, compared with crop and livestock production* (Dalgaard et al., 1998)

	Danish agriculture 1996	*Organic scenarios*					
		Present level of yield			*Improved level of yield*		
		0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Crop prod. (*bill. f.u.)*	15.9	11.0	11.4	11.6	12.3	12.8	12.9
Crop prod. (*PJ ME)* [a]	199	138	143	145	154	160	161
Livestock (*mill. l.u.)*	2.3	1.7	2.1	2.4	1.9	2.3	2.4
Energy for crop production (*PJ*)	37	17	17	17	17	17	17
Energy for livestock production (*PJ*)	41	13	29	41	14	31	37
Energy consumption, total (*PJ*)	78	30	46	58	31	49	54
Energy production (*PJ*)	14[b]	0	0	0	0	0	0
Net consumption (*PJ*)	64	30	46	58	31	49	54

[a] Converted from feed units into metabolised energy with the factor 1 f.u. = 12.5 MJ ME.

[b] There is a potential for further energy production in present-day agriculture, corresponding to the burning of the grain exported in 1996 (2 bill. kg * 15 MJ/kg = 30 PJ). Utilisation of this potential would have derivative socioeconomic consequences.

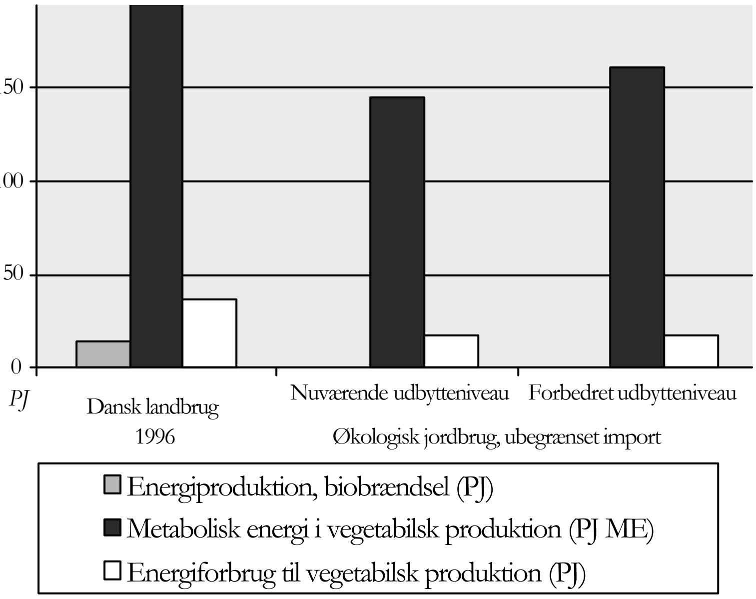
These calculations show that a switch to organic production could mean a reduction of 9 to 53% in net energy consumption, depending on the size of feed import and thus on the size of livestock production.

Energy can be defined in different ways

Energy consumption must be compared with the differences in production, as also shown in table 6.3. There is thus 20-30% less plant production in the organic scenarios compared with agriculture today. It is difficult to set up a complete energy balance for agriculture in which the energy in the different inputs and products are summed because energy cannot be precisely defined. For example, the energy in one kilo of clover used as cattle feed is not the same as if used for pigs or humans, and the calorific value is in turn different from the metabolic energy. However, generally speaking, there is a net production of energy in arable farming, whereas energy is consumed in livestock production.

while energy consumption per feed unit is lower in the organic scenarios

Figure 6.1 shows the energy production from biofuel and the metabolic energy in plant production in Danish agriculture in 1996 and in the two scenarios with the same livestock population, compared with the energy consumption for crop production. It will be seen that more energy is produced net in conventional arable farming. However, energy consumption per feed unit is considerably smaller in the organic scenarios than in present-day agriculture (see table 6.4). That is due in part to a different crop composition, in that it takes considerably less energy to produce feed units in clover grass than in, for example, cereals. However, also within the individual crops, energy consumption per feed unit is lower in organic production, mainly because industrially produced nitrogenous fertilisers are not used.



Conventional arable farming produces most energy

(Figure text)

Present yield level Improved yield level

Danish agriculture 1996

Organic farming Unlimited import

(Box text) Energy production, biofuel (PJ)
Metabolic energy in plant production (PJ ME)
Energy consumption for plant production (PJ)

Figure 6.1 *Comparison of energy production (PJ biofuel and PMJ metabolic energy) and energy consumption (PJ) in plant production in 1996 and in the two organic scenarios with the same livestock production (unlimited import)*

- just as energy consumption per livestock unit is lower

Total energy consumption per livestock unit, including energy for feed, is smaller in the organic scenarios than in present-day agriculture (table 6.4). In the scenarios in which the livestock production is maintained, that is mainly due to the smaller energy consumption in the domestic production of feed, but also to the fact that fossil energy is not used for heating in organic pig farming. In the other scenarios, the changed composition of livestock production also plays a role because, in pig farming, the energy consumption per livestock unit is approximately twice as big as in dairy farming (Dalgaard et al. 1998).

Table 6.4 *Energy consumption per produced feed unit and total energy consumption per livestock unit* (Dalgaard et al. 1998)

	Danish agricul-ture 1996	*Organic scenarios*					
		Present level of yield			*Improved level of yield*		
		0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Energy consumption per feed unit (*MJ/f.u.*)	2.4	1.4	1.4	1.4	1.3	1.3	1.3
Energy consumption per livestock unit (*MJ/l.u.*)	31	17	22	24	18	21	22

Organic arable farming is more energy-efficient, while conventional arable farming produces most energy per hectare

In an analysis of energy consumption in agriculture, it is important to be aware that arable farming, seen in isolation, produces a big energy surplus and that some plant products can be used for energy purposes. For example, cereals for burning contain much more energy than is consumed in their production. That applies in both conventional and organic farming. Organic production is more energy-efficient per kg cereal produced, while conventional farming produces most net energy owing to a larger yield. The energy content of the 2 billion kg cereal that was exported in 1996 (see table 5.3) corresponds to a gross calorific value of 30 PJ (Dalgaard et al. 1998). Burning instead of export would have derivative socioeconomic consequences.

Straw can be used as a fuel

In present-day agriculture (excluding rape, seed grass and peas) there is a surplus of straw amounting to about 1.8 billion kg, which is ploughed in. That is over and above the quantity of straw already used for energy purposes today. In the organic scenarios, straw is not used for energy purposes, although there is some surplus that could be used to maintain some of the present energy production from straw. In present-day agriculture there is a potential for increased use of straw for energy purposes, and one of the objectives of the government's biomass action plan is to increase that use of straw.

Table 6.5 *Straw production and straw consumption for feed and bedding in agriculture in 1996 and in the organic scenarios (billion kg)* (Alrøe et al. 1998a, Agricultural Advisory Service, personal communication)

	Danish agriculture 1996	*Organic scenarios*					
		Present level of yield			*Improved level of yield*		
		0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Straw production [a]	5.5	2.2	2.6	2.8	3.6	4.0	4.0
Straw for feed	1.9	0.4	0.4	0.5	0.3	0.4	0.4
Straw for bedding	0.8	1.0	1.5	1.8	1.2	1.7	1.8
Straw for energy purposes	1.0	0	0	0	0	0	0
Surplus straw	1.8	0.8	0.8	0.5	1.2	1.0	1.0

[a] Excl. rape and seed grass. Straw production in the organic scenarios is calculated in relation to present straw production, using a factor of 0.58 (=5.5 bill. kg straw/ 9.5 bill. f.u. cereal) times the yield in cereals and mixed seed.

- but many other factors have to be considered

Many other factors have to be considered concerning cultivation of agricultural crops for energy purposes, including the possibility of growing real energy crops and afforestation. A detailed discussion of biomass for energy in relation to organic farming is given in Christensen et al. (1996). The organic scenarios analysed in this report have not been designed for energy purposes. To clarify the role of agriculture as an energy producer it would be necessary to analyse conventional and organic scenarios that have energy production as one of their objectives.

6.2.2 **Greenhouse gases**

The simulated energy consumption has been converted into CO_2 emission and compared with the agricultural sector's emissions of CH_4 and N_2O (table 6.6). It will be seen that these two greenhouse gases are of considerably greater importance than CO_2. In the following we differentiate between domestic and foreign emission in the economic valuation (see section 7.4), with only the domestic emission valued in accordance with current international agreements in this area.

Domestic emission
- falls by 8-24%
The calculated fall in the agricultural sector's energy consumption would mean a corresponding fall in domestic CO_2 emission in some of the organic scenarios. The emissions of CH_4 and N_2O would also fall in some of the organic scenarios. However, it should be noted that these estimates are encumbered with great uncertainty, particularly in connection with the transition to a different form of production, such as organic farming. The difference in the emission of N_2O is due particularly to the size of the nitrogen turnover (see table 5.11). The emission of CH_4 is closely linked to the number of livestock, with ruminants as the biggest source. All in all, the calculated fall in domestic emission of greenhouse gases is 8 to 24% in the organic scenarios, measured in CO_2 equivalents (table 6.6) (Dalgaard et al. 1998).

Table 6.6. *Domestic and foreign emission of greenhouse gases in CO_2 equivalents per year (bill. kg)* (according to Dalgaard et al. 1998)

	Danish Agricul-ture 1996	*Organic scenarios*					
		Present level of yield			*Improved level of yield*		
		0% import	*15-25%*	*Unlimited*	*0% import*	*15-25%*	*Unlimited*
Domestic CO_2	2.5[a]	2.0	2.2	2.6	1.7	2.0	2.1
CH_4	6.7	5.6	6.1	6.5	6.0	6.6	6.7
N_2O	4.0	2.4	2.8	3.1	2.5	2.9	3.0
Domestic, total	13.2	10.0	11.1	12.2	10.2	11.5	11.8
Fertiliser etc.	0.9	0.2	0.2	0.2	0.2	0.2	0.2
Import of feed	1.5[b]	0	1.0	1.9	0	1.1	1.5
Foreign CO_2, total	2.4	0.2	1.3	2.1	0.2	1.4	1.8
Total emission	15.6	10.3	12.4	14.3	10.4	12.9	13.6

[a] The cost of producing the approx. 2 bill. kg grain exported in 1996 corresponds to 0.4 bill. kg CO_2.
[b] If the grain export is offset against the feed import on the assumption that the exported grain can substitute imported feed, the fall in feed import corresponds to a fall of 0.9 bill. kg CO_2 (exported grain / imported feed * 1.5 bill. kg CO_2).

- and the foreign emission falls sharply with import of feed
In the global CO_2 account, the emission of CO_2 in other countries that is connected with Danish agricultural production also counts. Table 6.6 shows the breakdown of the foreign emission of CO_2 between production of fertiliser and machines and import of feed. It will be seen that there is less foreign emission in the organic scenarios and that a smaller livestock population as a consequence of a smaller import of feed results in less CO_2 emission in other countries in the organic scenarios. This raises the question of whether a switch to organic farming in Denmark would result in increased production in other countries, which would reduce the effect on the global CO_2 account. The feed import in Danish agriculture 1996 could to some

extent be substituted by the grain that is exported, which would reduce by up to 0.9 bill. kg the CO_2 emission in other countries that is connected with the production of the imported feed. Alternatively, with increased use of crops for energy purposes, a considerable saving could be achieved in the net energy consumption in Danish agriculture and thus a fall in the domestic emission of CO_2 – to the extent that this energy production substitutes fossil fuel. The fall in CO_2 emission with use of the cereal that is at present exported for energy production thus corresponds to approximately the present domestic CO_2 emission of 2.5 bill. kg (table 6.6).

Alternative use of cereal export would have a significant effect on these calculations

6.3 Nature content – effect on fauna and flora

In this section we summarise the consequences of total switch to organic farming for flora and fauna in both cultivated and uncultivated land in the Danish rural landscape.

Natural content affected dif-ferently in the different types of biotope

To describe the natural status and relations it is necessary to look at the country, the regions and the farms etc. as a unit from the point of landscape ecology. At the same time, it is important to separate the main types of biotope in the agricultural landscape when evaluating the natural potential of restructuring for organic agriculture. These main types of biotope are fields in rotation, semi-natural ecosystems and both these types of biotope's immediate neighbours, the small biotopes. Because of their small size and shape, the small biotopes are normally characterised by a high edge: area ratio, which makes them particularly sensitive to impacts from production in neighbouring areas (Reddersen 1998).

6.3.1 Set-aside acreage

The density of individuals would increase relatively rapidly in fields in rotation

In acreage in rotation, *quantitative* changes – an increase in the density of individuals – would occur relatively rapidly after conversion (within one to a few years). This applies to both weed flora and insect fauna. The total densities of individuals would then presumably "stabilise" at a new, higher level. The other higher fauna, vertebrate fauna, are only rather peripherally or periodically attached to fields in rotation and would therefore react less, less certainly and less quickly. However, some field specialists could also react positively and relatively quickly (Reddersen 1998).

and, in the slightly longer term, the species diversity would also increase - although most in the case of relatively common species

Owing to the generally big ability to spread in rotation-field species, *qualitative* effects in the form of recolonisation and immigration of new species would also occur immediately after conversion and would continue, gradually increasing in the short and medium term, and then stabilise. The diversity of species of both flora and fauna would thus very probably increase significantly in a fully organic scenario. However, a large part of the increased diversity would consist of species that were already relatively common. In this development, a few species within all groups of flora and fauna might become less numerous – calculated as individual densities. Such species include certain pests and pathogens such as aphids and mildew, but undoubtedly also certain neutral species. However, they would not be of any great significance in the big picture.

The increase would be due mainly to the absence of pesticides

The complete discontinuation of the use of *pesticides* would play a vital role in the increased density and species diversity – including some well-known pests and pathogens. However, harmful insects and their frequency depend on other factors as well, such as soil preparation, rotation, choice of variety and variety mixtures, biological control and the biochemistry of the crop, which is affected by the supply of nutrients. Without pesticides one would avoid the direct toxic effects – including, particularly toxic effects on the main species, which are not harmful. At the same time, one would avoid the often equally big, indirect, non-toxic effects, where organisms higher up in the food chains are deprived of their basis for life in the form of food, shelter, etc.

The above benefits from the absence of pesticides are deemed to be far greater than the negative effects that can be caused by other forms of weed control. However, a few sensitive organisms within all groups of flora and fauna would be harmed by mechanical soil treatment, flame treatment and similar (Reddersen 1998).

- while it is more difficult to assess the changes in rotation

It is more difficult to assess the effects on the natural content of the changes in the *crop rotation.* The species composition of sprouting weeds would depend on the crop rotation and the individual crop, but, conversely, the seed bank could have a strongly moderating effect. It is judged that the organic crop rotation would offer conditions of life to several different types of weed – considered over the entire crop rotation. A larger proportion of spring crops combined with more frequent preservation of stubble fields over the winter is deemed to be of great importance for a number of less common but mainly unproblematic species of weed and, at the same time, of benefit to the real field bird species and birds spending the winter in Denmark. The expected increased proportion of clover grass/lucerne crops would easily replace the lost rape as important winter larder from some birds and mammals. The increased proportion of perennial crops would be of great advantage to some field insects with a long life cycle that spend the winter in the soil, including a few well-known harmful insects (Reddersen 1998).

In small biotopes and semi-natural ecosystems
- the absence of pesticides

6.3.2 **Semi-natural ecosystems and small biotopes**

Organic farming differs from conventional farming in two ways:

1. by ensuring against direct placing or drift of *pesticides* to both small biotopes and semi-natural ecosystems. In these biotopes, well-preserved vegetation is essential for the ecosystem. The plant species, in particular, are extremely sensitive to herbicides – acutely because of high sensitivity and in the long term because of poor possibilities for recolonisation as a consequence of a low dispensability and a small and short-lived seed bank.

- reduction of fertilisation
- and no longer any centrifugal spreading of fertiliser
play a role

2. through a considerable reduction in the placing and drift of *fertilisers* to both small biotopes and semi-natural ecosystems. Drift to edge biotopes would be effectively reduced without centrifugal spreading of fertiliser. On the other hand, organic dairy farmers also need to control local sources of ammonia deposition that can be deposited along windbreaks. It can be assumed that the shortage of fertilisers would effectively stop the placing of fertiliser in semi-natural ecosystems because other crops would be prioritised.

and grazing would be important
With the extensive use of grazing in organic farming, it can be assumed that semi-natural ecosystems would also be grazed, which would be necessary to ensure a light, warm microclimate and avoid overgrowing.

- but there is great "organic inertia"
It is important to stress that very great "ecological inertia" must be expected after earlier damage to the natural content of small biotopes and semi-natural ecosystems, especially to the vegetation, because of maintained eutrophication in the nutrient pool and slow recolonisation. Although organic farming could protect remaining natural assets, one could only in the very long term expect any real nature restoration effect on impoverished land. (Reddersen 1998)

6.3.3 **Landscape in general**

Considerable change in landscape ethic
In a 100% organic agricultural sector there would be a diversified crop rotation and grazing animals all over the country. The landscape ethic would thus be very different from Danish agriculture today, where production is far more specialised.

An example of the consequences of the expected changes in both crop-rotation acreage and semi-natural ecosystems is the consequences for the number of birds. Braa et al. (1988) thus found that among characteristic farmland birds there were 2-3 times as many individuals on organic farms than on conventional farms. However, Reddersen (1998) finds that this difference is not due to the absence of fertiliser and pesticides but, rather, to the landscape’s mosaic (structural diversity). The significance for the fauna is described further in the report from the Sub-committee on Environment and Health.

6.4 The biology of the soil

The biology of the soil is here defined as including those organisms that belong to the soil’s metabolic food chain, i.e. microorganisms (bacteria and fungi), macrofauna (protozoa, tardigrades and nematodes), mesofauna (cellemboles, mites and enchytrae), together with macrofauna (earthworms). Insects that have one or more stages of life in the soil or that live above the soil (e.g. species of flies, gnats and beetles) are not included.

The soil’s organisms are of importance to the fertility and structure of the soil
- and the food chain

Microorganisms play an important role for soil fertility and would be of critical importance to a wide range of cultivation factors in organic farming. The metabolism of the soil's organic matter can primarily be attributed to microbial activity. The microorganisms play a vital role in the structure of the soil and provide food for many of the soil fauna. Springtails (collemboles) and mites increase the rate of liberation of nitrogen etc. accessible to plants from the soil's pool of organic matter by grazing on the microflora, and they play a role as prey for predators in the springtime, when other sources of food are in short supply. Earthworms are of great importance to the structure and fertility of the soil. They are the first link in the decomposition of plant parts and play a major role in the physical structure of the soil by making passages that affect the ability of the soil to suck up water and lead it away.

Effect of restructuring
- depends on the type of farm
The quantity of organisms in the soil depends on a wide range of factors – for example, the type of soil, type of fertiliser, crop rotation, soil preparation, climate, season, etc., and it is therefore extremely difficult to determine what is the effect of organic production in itself and what is due to other factors. Only in the case of microorganisms are there sufficiently comprehensive studies to provide good estimates of effects across all these factors. These studies have been included to some extent, but it should be noted that they have not been fully processed statistically. For the other groups we have mainly assessed the effect of restructuring by assessing the effect of changes in crop rotations. This means that the biological consequences of converting to organic production would depend very much on the type of farm that was there already. Converting from conventional production with a balanced livestock population and mainly use of manure for organic production would not result in such big changes in the biological conditions as converting from conventional arable farming without the use of manure and with what is usually a one-sided crop rotation.

A considerable increase is expected
The effects of restructuring have been calculated by summing the effects of restructuring from different types of farm in present-day agriculture to 100% organic farming with a crop rotation as described in chapter 5, taking into account the distribution of the types of farm with respect to types of soil. The total estimates of the effect of restructuring must be regarded as rough estimates because a wide range of sources of variation have not been taken into account here. For the country as a whole it is estimated that the microbial biomass would increase by 77%, the density of collemboles by 37%, and the density of earthworms by 154% (Axelsen & Elmholt 1998).

- mainly as a consequence of changed crop rotations
It would thus be possible to considerably increase life in the soil by converting to organic production. In the calculation of the effect on collemboles and earthworms, account has only been taken of changed crop rotations. In other words, any effects of the organic form of production besides crop rotation and type of fertilisation, including the effect of using pesticides, would increase the effect of restructuring. Besides the crop-rotation effect, there would probably also be an effect on microbial biomass and earthworms, since scientific studies point in that direction. An effect of organic production on the microbial biomass should also penetrate to the mesofauna (collemboles, mites and enchytrae) or to parts of the mesofauna, since many species from

this group of fauna live on microorganisms. There are just no studies to confirm or disprove that (Axelsen & Elmholt).

6.5 Health consequences of plant products

There is not a sharp dividing line between organic and conventional production
- and different perceptions of health
In this section we shall look at possible health consequences of differences between the organic and the conventional form of cultivation. However, it is not possible to differentiate sharply between organic and conventional production because, in some respects, some forms of conventional production do not differ significantly from the corresponding organic production. On the other hand, the organic perception of health differs considerably from the analytical approach used here to look at the health consequences, with the focus on the content and effect of the various physiologically important substances. Seen from the point of view of the original organic movement, the health concept covers the entire relationship between diet, farming and environment, and changes in diet are closely connected with how the food is produced, which is reflected in the consumers' preferences (Kølster et al. 1996).

A health difference has not been proven
- our knowledge is limited
There are no published studies that show definitively whether there is a health difference between plant products from organic and conventional production. A qualitative review has therefore been carried out of the known knowledge concerning the importance of cultivation factors to the content of physiologically important substances, including the so-called secondary metabolites, and an assessment is given here of whether, on the basis of that knowledge, we can expect differences of an order of magnitude that would be of importance to health. Here, it is a problem that our knowledge about the importance of the individual substance to health is in many cases limited, partly because the importance of some substances has not been fully clarified, partly because most of the substances that have been thoroughly studied, e.g. vitamins, are only beneficial if there is otherwise too little of them in the diet and partly because it is not possible to divide natural components into health-promoting and harmful substances; most of the possibly health-promoting components also have certain toxic effects in themselves, and, paradoxically, these may be a condition for their health-promoting effects (Veterinary and Food Directorate 1999).
- and health-promoting substances are often also toxic
The cultivation conditions that are known to be of direct and indirect importance to the content of physiologically important substances including the supply of nitrogen, the type of fertiliser and the use of pesticides.

A possible effect of restructuring for organic production
When considering the importance of the entire form of cultivation, across crops and products and on the basis of the available knowledge, the main question is whether differences in the form of cultivation can generally be expected to result in a significant difference in the population's *intake* of groups of substances that are generally regarded as beneficial or harmful. That gives a qualitative assessment of the possibility of a health benefit or the

reverse with switching to organic production, but with our present level of knowledge, it is not possible to say anything about the magnitude of a possible effect (Brandt el al. 1998).

- depends on the content of substances and intake of the food product
If there proves to be a difference in the concentration of physiologically important substances in a food product, the effect on the population's intake of a substance with restructuring for 100% organic production would be the product of changes in the content of substances and changes in the intake of the food product, with the latter in turn depending on the price relationship. For a final assessment of the health consequences for the population and domestic animals, it is therefore also necessary to take food and feed prices and consumer preferences into account.

The differences are generally small compared with other changes in the diet
The general conclusion is that 100% organic production can be expected to result in a number of changes in the content of substances that are important to human and animal health. Some substances can have a beneficial effect on health, and others an adverse effect. However, the differences are generally small – they are expected to be far smaller than the effect of the cultural changes in the composition of the diet that have taken place in the last 50 years (Brand et al. 1998).

6.6 **Consumption of veterinary drugs**

Different types of veterinary drugs are used
- with most use of growth promoters
A number of veterinary drugs are frequently used in Danish agriculture. Besides the therapeutic treatment of diseases, a number of substances are also used as growth promoters. Growth promoters are usually antibiotics, but they can also be compounds of copper or zinc. They are given regularly to the individual animals in their feed or drinking water, primarily in order to affect the bacterial flora in the gastrointestinal tract, so that the animals grow faster and make better use of their feed. The consumption of prescription drugs and antibiotic growth promoters for domestic animals in 1996 is shown in table 6.7, broken down into groups, with an indication of the most commonly used preparation in each group. As will be seen from the table, the consumption of antibiotics as growth promoters at that time was almost twice the consumption of antibiotics for treatment of diseases in domestic animals.

The use of growth promoters ends
Restructuring for organic production would result in a considerable reduction of the consumption of antimicrobial substances in livestock production. The main reason for the reduction would be an end to the use of antibiotic growth promoters, which, in 1997, accounted for more than half of the consumption of antimicrobial substances in livestock production. The consumption of antibiotic growth promoters is expected to be phased out in 1999 on the basis of voluntary schemes agreed within the various branches of Danish agriculture.

Table 6.7 *Consumption of prescription drugs, antibiotic growth promoters and antiparasitic products for livestock (kg active ingredient per year), and a breakdown of the consumption into types of animals (Bennedsgaard et al. 1998)*

Type of veterinary drug Scope	*Total consumption in 1996*	*Breakdown into types of animals*
Hormone treatment	27	Mostly for dogs and cats
Central nervous system	237	
Digestion and metabolism	1,456	
Antibiotics (in feed)	1,706	Aquaculture (80%), poultry (20%)
Antibiotics (growth promoters)	105,548	Pigs (>95%)
Antibiotics (veterinary drugs)	48,676	Pigs (65-70%), cattle (25%)
Coccidiostatics (antiparasitic)	13,600	Broilers
Other antiparasitic products	?	Cattle and pigs

[a] A prescription is not required for antiparasitic products and there are no official figures for the consumption.

- the consumption of therapeutic antibiotics would fall by about 30%
It is estimated that the consumption of therapeutic antibiotics would also fall in the event of a switch to organic production. Changes in the consumption per animal are shown in table 6.8. In all, it is estimated that consumption would fall by about 30% if livestock production were maintained at the present level and by more with a smaller pig production. An estimate of the total consumption after restructuring, with pig production halved, is shown in table 6.8 (Bennedsgaard et al. 1998).

However, the estimate is very uncertain, due in part to limited experience with organic production of fatteners. Extended retention time in connection with treatment and restrictions on the access of owners to treat sick animals themselves are expected to lead to a changed treatment pattern that will result in a lower consumption of antibiotics. A lower level of yield in milk production, free-range bullock production and free-range pigs are also expected to reduce the occurrence of infectious diseases.

***Table 6.8** Change in consumption of antibiotics per animal with restructuring for organic production and estimate of the total consumption with pig production halved (kg active ingredient per year) (Bennedsgaard et al. 1998)*

Production	*Consumption per animal as % of present consumption*	*Total consumption with pig production halved*
Dairy cows Calves Bullocks	75-85% 75% Not known	10,000
Sows and piglets Fatteners	40% 70-80%	8,000-12,000
Egg layers Broilers	No consumption No consumption	
Other (sheep, goats, mink, hobby animals)	Unchanged	3,500

- and consumption of antiparasitic products is also expected to fall
Consumption of antiparasitic products for pigs is expected to fall in step with pig production. Consumption for cattle would fall because preventive treatment would no longer be used, but it is not possible to estimate the size of the reduction owing to lack of knowledge concerning the present use and uncertainty about the consumption of antiparasitic products in connection with the transition to fattener production (Bennedsgaard et al. 1998).

Effect on the environment insufficiently clarified
but it is assumed that discontinuing the use of growth promoters will reduce the development of resistance
The effect on the environment of residual concentrations of veterinary drugs is generally insufficiently clarified. However, effects have been detected on the insect fauna and the decomposition of cowpats from use of the antiparasitic product Ivermectine and on microbiological processes in compost and biogas as a consequence of the use of growth promoters. It has been found that discontinuing the use of antibiotic growth promoters results in less resistance development both in pathogenic bacteria and environmental bacteria and, to a lesser extent, a reduction in the occurrence of resistant bacteria. It must thus be assumed that discontinuing the use of growth promoters will reduce the occurrence of antibiotic-resistant bacteria in livestock, including bacteria that are pathogenic to humans, and reduce the risk of resistant genes being transferred to bacteria that are pathogenic to humans. However, there are no studies that quantify the occurrence and importance of this in relation to direct development of resistance in connection with antibiotic treatment of humans. Increased outdoor production of pigs and poultry in connection with restructuring for organic production could possibly result in a slightly increased risk of certain diseases spreading from animals to humans (zoonoses) (Bennedsgaard et al. 1998).

6.7 Summary and conclusion

A number of environmental consequences of a total switch to organic farming in Denmark can be documented, although knowledge is lacking in many areas.

The consequences of a phase-out of pesticides are described in the report from the Sub-committee on Environment and Health. This chapter should be seen as a supplement to that report since we have tried to describe the possible further consequences of a changed crop rotation and phasing-out of fertilisers.

Supply of nitrogen to the soil reduced by 50-70%
The calculations showed a 50-70% reduction of the net contribution of nitrogen to the soil in the organic scenarios compared with Danish agriculture in 1996. Against this background, we would have to expect a significant reduction of nitrogen leaching in the long term, retaining the same cultivation practices. It should, however, be noted that the calculations are encumbered with great uncertainty.

- and energy consumption reduced in step with production
The consumption of fossil energy and production of greenhouse gases would drop in step with the scale of livestock production. In addition, energy consumption per unit produced in both plant and livestock production would fall, mainly because of the changed composition of crops and because manufactured nitrogen fertilisers would not be used. On the other hand, if some of the crops were used for energy purposes, there would be a bigger net energy production in conventional arable farming because of the higher yield.

The quantity and diversity of the flora and fauna would increase
- but there is great "ecological inertia"
A complete switch to organic farming would result in larger quantities of flora and fauna in crop-rotation fields. Species diversity would gradually increase, although mainly in species that are already rather common. The biggest qualitative effects would be found in semi-natural ecosystems and in small biotopes because there would no longer be any spreading and drift of pesticides or unintentional delivery of top-dressed artificial fertiliser to edge biotopes. However, a very big ‘ecological inertia’ must be expected after earlier damage to the natural content of small biotopes and semi-natural ecosystems, especially to the vegetation, because of maintained eutrophication in the nutrient pool and slow recolonisation. Although organic farming can be assumed to protect remaining natural assets, one could only in the very long term expect any real nature restoration effect on impoverished land.

The quantity of organisms in the soil increases considerably
A considerable increase in the quantity of organisms in the soil can be expected with a switch to organic farming, mainly because of changed crop rotations. Microorganisms and the soil fauna play an important role for soil fertility and would be of critical importance to a wide range of cultivation factors in organic farming. The metabolism of the soil’s organic matter can primarily be attributed to biological activity. Microorganisms and earthworms play a vital role in the structure of the soil. The subsoil's fauna play a role as food for predators above the ground.

Changes in the intake of physiologically important substances will be small

The consequences for public health of a total switch to organic farming would depend on changes in the intake of physiologically important substances, which in turn would depend partly on changes in the food products' content of substances and partly on changes in the population's intake of different food products. Changes in consumption would depend on various circumstances with and without connection with the conversion. A number of changes can be expected in the content of physiologically important substances, but the effect of these changes would be generally small compared with the effect of changes in the composition of the diet.

Use of growth promoters will end
- and consumption of therapeutic pharmaceuticals will fall by 30%
Use of antibiotic growth promoters would end altogether with a total switch to organic farming. It should be mentioned, however, that the use of growth promoters in conventional farming is going to be phased out in 1999. Overall, it is estimated that the consumption of therapeutic pharmaceuticals would fall by around 30% with unchanged livestock production and further still with falling livestock production. Discontinuation of the use of growth promoters is presumed to reduce the risk of transference of resistant genes to bacteria pathogenic to humans.

7 Consequences for production, economics and employment

Primary agricultural production has been described in chapter 5 for six different scenarios for 100% organic farming in Denmark. In this chapter we will look at the economic consequences of these scenarios and the consequences for employment.

Socioeconomic consequences difficult to predict
It should first be emphasised that it is extremely difficult to predict the socioeconomic consequences of 100% organic farming because the change is a very big one, with both primary production, the foodstuffs industry and a number of associated sectors affected to a greater or lesser extent.

The consequences depend on
- the size of the production
- the price of the products
- and environmental benefits
The economic and employment consequences depend on both the size of the production and the price of the products, including both the price ex farm and the value addition that occurs in the secondary industries. Lastly, there may be an environmental benefit that can be valued. In the following we will look at the market perspectives (section 7.1) and the socioeconomic consequences under different assumptions (section 7.2). The economic consequences at farm level will be illustrated by examples of conversion of some different types of farm (section 7.3). In section 7.4, some different environmental benefits will be valued.

- whereas account is not taken of the structural changes
In the organic scenarios, ”de-regionalisation” of Danish livestock production with a 30-year time horizon is assumed, in that the manure is assumed to be evenly distributed in relation to the crop rotations (see chapter 5). There would also be a need for substantial restructuring in the food industry and other associated sectors. These restructuring costs have not been included in the economic analyses. It is thus assumed that conversion to organic production takes place in step with the wearing down and depreciation of the existing capacity.

7.1 Market perspectives

The market is growing
The Danish market for organic food products has developed in a very interesting way in recent years. In the 1990s, it grew from very limited quantities to the market shares shown in table 7.1. It will be seen that there are big differences between the various products – from 0 to 22% of the market. In the case of milk, eggs and plant products, for example, the market share is more than 10%, whereas organic meat, particularly pork, has only a marginal share of the market (less than 2%). Today, organic products account for around 3% and 4% of total food sales and 5% in the case of the

product categories in which organic products are offered (Ministry of Food, Agriculture and Fisheries 1999).

Table 7.1 *Market share of selected organic products (The Ministry of Food, Agriculture and Fisheries 1999)*

Product	*Market share, end 1997 (%)*
Rye flour	22.0
Milk	20.0
Oats	17.5
Eggs	13.0
Carrots	10-12
Wheat flour	11.0
Sour milk	7.5
Potatoes	7
Onions	3
Cheese	2-3
Butter	2.0
Beef	2
Pork	<1

- and the products are sold at premium prices
Organic food products are sold at a higher price than corresponding conventional products. Table 7.2 shows the price premiums paid to farmers (ex farm) for some selected products. It will be seen that the price premium varies somewhat, both between products and within products. The price premium for milk has been the most stable at around 25% for most of the milk in recent years.

Table 7.2 *Price premiums in per cent ex farm from 1994 to 1996 for organic products compared with conventional products* (Borgen 1998)

Product	*% price premium*
Cereal	60 – 90
Milk	20 – 30
Beef	5 – 25
Pork	35 – 80

- that vary a lot
The price premium paid by the consumers (in the retail trade) varies greatly and is characterised by the fact that some organic products are small niche products. As the market share of organic products increases it must be assumed that the middlemen’s mark-ups on organic products will approach those on conventional products. With that, the premium paid by the consumers will gradually fall.

It is difficult to predict the future market
There are only a few market surveys describing the future possibility of increased sales of organic products. It is therefore extremely difficult to predict how the market will develop in the long term. According to the Ministry of Food, Agriculture and Fisheries (1999), the Danish organic

market is furthest ahead with respect to both size of production and sales. However, a similar development is going on in a number of other countries in Western Europe. The UK and Germany, together with the USA, are of particular interest as potential markets for exports of Danish organic products (Ministry of Food, Agriculture and Fisheries 1999, Abrahamsen & Ingemann 1998).

- but there are export opportunities

Abrahamsen & Ingemann (1998) estimate that, in 1998, sales of organic food products in a number of Western countries totalled DKK 80 billion, or about 1% of the entire food market, and that there was an import demand of the order of DKK 15 billion. On the basis of studies of major export markets, the authors estimate that the relative price premium will have to fall by 10-25% at the retail level to enable continued strong growth in the market share of organic food products. If demand in the coming decade develops in the same way as in the last few years, we could see a tenfold increase in sales in the same markets. However, it must be stressed that this prediction is encumbered with great uncertainty; it is based, for example, on an assumption that the consumers compose their consumption not only with a view to satisfying their material needs with different products but also on the basis of their values, including a preference for the organic form of production.

Values are changing

Abrahamsen & Ingemann (1998) find that fundamental changes are taking place in people's values in the highly developed industrial countries. This means that these societies are gradually moving in a new direction owing to ever higher prioritsation of "soft" values, such as quality of life, self-realisation and environmental protection. This gradual change in values has been noted both in society as a whole and at the individual level, and it is affecting people's political attitudes and their actions as consumers.

- and the process is gaining importance in line with the product

Communication and trust are therefore important

As an element of this change in values, understanding of sustainability is influencing the development of the consumers' values and thus the development of demand. As a result, *the production process* is gaining importance in line with *the product,* so that the consumers' perception of the quality of a product covers both product and process. The production process is accordingly expected to meet a given, value-based standard, at the same time as requirements are made concerning the quality of the product itself, i.e. the more traditional perception of quality. The production process is therefore becoming not simply a means of producing a given product but, equally, a goal in itself. From this it follows that the quality of the production process must be communicated to the consumers because it cannot be seen directly from the product itself. The consumers must therefore trust that the production process is actually as expected. This also applies to the extent that the preference for organic food products is based on individual health considerations.

- and it can be achieved through nearness or certification

The consumers' trust that all levels of the production process are in accordance with the organic rules can be gained through nearness and/or certification. By nearness we mean that the food products are produced and sold locally. This strategy is most suitable for small enterprises. Large companies must primarily depend on certification, which means that the consumers' trust depends greatly on the efficacy of the inspection system. Many surveys show that there is today great faith in the government Ø-label (organic label) in Denmark (Ministry of Food, Agriculture and Fisheries 1999). Here, however, it is also important to remember that other environment-friendly and animal-friendly systems have been developed as well as the organic system. All the same, organic farming is the only system that is based on a unique and internationally accepted concept for which international production, certification and sales structures have been developed.

Europe leads the way
- Denmark also among the leaders
The European agricultural sector must generally be regarded as well ahead of the pack in the development of organic production, measured by total converted acreage or by the proportion of the acreage converted (Abrahamsen & Ingemann 1998). However, there are big differences in both the rate of conversion and the proportion of acreage converted up to the present time. Austria stands out, with respect to both rate of growth and proportion of acreage converted. It is followed by Sweden, Finland, Spain, Denmark and Germany, in that order. However, the converted acreage can naturally not be used as an indication of whether the individual pioneering countries might be potential competitors of critical importance to Danish organic production.

- with possibilities for export
Similarly, it is not possible to derive from the rate of conversion any information about the technological level and thus competitive positions with respect to the development of process technology and the derivative export opportunities. However, Denmark must be assumed to be the country that could best make use of possibilities for assuming a central position in important export markets since it is the only country among the pioneers that has a production capacity and an institutional base that are targeted on extensive exports. However, it must be stressed that other countries are thinking about promoting conversion to organic production with a view to competing for these markets (Abrahamsen & Ingemann 1998).

Abrahamsen & Ingemann (1998) judge that the necessary technology for primary production, processing and distribution of organic food products is in place in Denmark and that Denmark also has competencies and an institutional network in connection with its existing agricultural production that can be used for further development of production and marketing. That depends, however, on the existing institutions being willing to switch tracks technologically.

7.2 **Socioeconomic consequences**

Analyses based on a general equilibrium model
The sectoral and socioeconomic consequences are clarified in a number of analyses using the general equilibrium model (AAGE) developed and used by researchers at the Danish Institute of Agricultural and Fisheries Economics

(DIAFE) to describe the socioeconomic consequences of various agricultural measures

The calculations with the AAGE model primarily throw light on the socioeconomic costs that would arise from the fall in primary production. The analyses are based on “compulsory” conversion to organic production because that would be the only sure way of achieving 100% conversion. Any preferences the Danish consumers may have for organic farming have thus not been valued. On the other hand, a sensitivity analysis has been carried out in which it is assumed that foreign consumers’ preferences change to the benefit of Danish organic products.

The AAGE model has also been used to clarify the phase-out of pesticides. A detailed description of the model’s assumptions and mode of operation are given in the report from the Sub-committee on Production, Economics and Employment (Danish Environmental Protection Agency 1999c, Jacobsen & Frandsen 1998).

Despite being based on the same model theory, the analysis of restructuring for organic production differs greatly from the analyses of the phasing out of pesticides. The reason for this is more limited knowledge about a number of actual economic relationships at farm level in connection with a total restructuring of Danish farming for organic production. Similarly, such restructuring would also imply considerably more far-reaching structural changes in Danish agriculture. The calculated socioeconomic consequences are therefore also encumbered with considerable uncertainty compared with the calculated sectoral and socioeconomic consequences of a reduction in the use of pesticides. The uncertainty associated with the calculated consequences is naturally also a result of the assumptions that must necessarily be included in such model calculations, and the results are therefore only an expression of the direction and order of magnitude of the socioeconomic consequences of a total restructuring for organic production.
- that expresses only the direction and order of magnitude

The model has been used on four scenarios
The AAGE model has been used on 4 scenarios: 0-import, 15-25% import with the present and improved level of yield (see table 5.1 for a more detailed specification of the production), and with the following assumptions:

- primary production corresponding to the four scenarios (exogenous production)
- unchanged consumer preferences, i.e. a special market for organic products is not assumed
- a unilateral Danish approach, i.e. there are conventional prices for both exported and imported products.

- and a sensitivity analyses with a price premium on exports
A sensitivity analysis has also been carried out in which changed consumer preferences in the export markets are assumed, corresponding to a price premium of 10% on milk and beef and 20% on pork and poultry. This calculation was only carried out with 15-25% import and improved yield level.

The assumed fall in production
The two scenarios with import corresponding to an unchanged livestock population have been omitted, partly due to problems in handling different

prices for the imported feed. In that connection, it should be mentioned that the scenario with 15-25% import and improved yield level is very close, with respect to production, to the scenario with unchanged livestock population (see table 5.1) and will therefore give a good indication of the economic consequences, also with unchanged livestock population. The changes assumed in the four scenarios compared with Danish agriculture today are shown in table 7.3. It will be seen that the total, weighted fall in the volume of production varies from 10 to 34%. A detailed description of the scenario set-up is given in Jacobsen & Frandsen (1999).

Table 7.3 *Assumed changes (%) in agricultural production* (Jacobsen & Frandsen 1999)

	Present level of yield		*Improved level of yield*	
	0-import	*15-25% import*	*0-import*	*15-25% import*
Cereal	-62.0	-53.8	-52.9	-44.7
Rape	-3.2	-100.0	-11.6	-100.0
Potatoes	-79.8	-79.8	-79.8	-79.8
Sugar beet	-54.4	-54.4	-54.4	-54.4
Greenfeed	57.6	53.7	66.0	63.4
Dairy farms	0.0	0.0	0.0	0.0
Pigs and poultry	-69.1	-29.2	-54.3	-7.2
Total	*-33.8*	*-20.4*	*-26.2*	*-10.1*

7.2.1 **Fundamental consequences of a restructure**

Compulsory conversion to organic production would have considerable consequences for the whole of primary agriculture (see table 7.3). One would thus expect a marked reduction in plant production and, depending on the development of productivity in plant production and the rules for import of feed for livestock farming, the production of pigs and poultry. A considerably lower production of pigs, in particular, would have serious consequences for employment in primary production and processing in this area, and a number of supply industries would experience a fall in the demand for goods and services for primary agriculture.

- has derivative consequences

With the given preferences and use of present technology, restructuring for organic production can be equated with a fall in productivity in primary agriculture and the traditional, derivative consequences of that. This means an increase in unit costs in agriculture, resulting in increasing production costs. This would reduce the sector's competitiveness, resulting in increasing imports and falling exports, which would directly impair the balance of payments. The extent of the fall in the net export of agricultural products would depend greatly on the intensity of the competition on the international food markets, including whether one is talking about 'bulk goods', such as grain, or more differentiated products, such as pork and dairy products. The overall effect on the balance of payments would depend on the overall impact on imports and exports, including changes in export and import prices.

The consequences for employment in primary agriculture would depend on the relationship between, on the one hand, falling production in terms of quantity and, on the other, more labour-intensive production per unit with conversion to organic production. There is little doubt that the former effect would dominate in the event of total restructuring, which means that total employment in primary agriculture would fall. In addition, employment in the processing industries (e.g. abattoirs) would fall in step with the fall in production.

That would mean a fall in real wages, GNP and private consumption
Socioeconomically, rising prices for agricultural products and falling nominal wages (due to reduced employment in primary agriculture and the processing sectors and the assumption of unchanged employment in the long term) mean that real wages would fall in connection with such a negative productivity impact. Correspondingly, real GNP and private consumption would fall as a consequence of lower remuneration of the primary production factors. The result, in the longer term, would be a smaller capital for a required outcome (interest rates are set abroad). If the balance of payments were impaired as a consequence of possible total growth in imports and falling exports, combined with changed terms of trade, financial policy would have to be tightened to achieve equilibrium on the balance of payments.

- depending on yield levels
- and preferences
These sectoral and national consequences naturally depend on the magnitude of the assumed loss of productivity that would result from restructuring for organic production. If it is assumed that the present yield level could be improved with a restructuring of the whole of Danish agriculture for organic production, such a development would naturally partially counter the above-mentioned economic consequences. Similarly, a change of preferences, particularly among foreign consumers of agricultural products to the benefit of Danish organic products would also reduce the economic costs in connection with a restructuring of Danish agriculture for organic production. All else being equal, such a change would increase the value of the net export of Danish goods and services, with derivative favourable consequences for the Danish economy.

Table 7.4 *Changes in prices and exports (%) of primary and processed agricultural products* (Jacobsen & Frandsen 1999)

	Prices				*Export*			
	Present yield level		*Improved yield level*		*Present yield level*		*Improved yield level*	
	0-import	*15-25% import*	*0-import*	*15-25% import*	*0-import*	*15-25% import*	*0-import*	*15-25% import*
Primary agricultural products:								
Cereals	91.3	43.2	91.3	34.2	-100.0	-100.0	-100.0	-100.0
Greenfeed	12.9	11.4	5.3	-4.1				
Beef	-0.9	-0.4	-0.9	-0.4				
Milk	0.4	0.2	0.3	0.1				
Pork	48.4	17.3	49.4	14.0				
Poultry and eggs	58.3	40.6	59.0	32.5				
Processed agricultural products:								
Cattle slaughtering	-1.5	-0.8	-1.3	-0.6	5.9	3.2	5.1	2.2
Pig slaughtering	27.0	9.4	27.9	7.8	-90.8	-38.7	-70.0	-5.9
Dairies	-1.0	-0.7	-0.8	-0.4	4.0	2.6	3.0	1.6

Table 7.5 *Economic consequences of organic agriculture, present yield level* (Jacobsen & Frandsen 1999)

	1992 level	*0-import*		*15-25% import*	
	Bill. DKK	*Bill.' 92 DKK*	*Per cent*	*Bill.' 92 DKK.*	*Per cent*
Real GNP	887.9	-26.5	-3.0	-17.4	-2.0
Real private consumption	439.3	-24.4	-5.5	-16.2	-3.7
Real public consumption	229.0	0	0	0	0
Real investments	161.0	-4.4	-2.7	-2.5	-1.6
Real export	324.2	-1.6	-0.5	-0.1	0.0
Real import	265.6	-6.6	-2.5	-3.1	-1.2
Real capital			-4.5		-2.6
GNP deflator			-2.9		-1.9
Consumer prices			-2.1		-1.5
Price of investment goods			-2.5		-1.6
Terms of trade			-1.6		-0.8
Money wages			-4.8		-3.1

Table 7.6 *Economic consequences of organic agriculture, improved yield level* (Jacobsen & Frandsen 1999)

	1992 level	*0-import*		*15-25% import*		*15-25% import +10/20% export prices*	
	Bill. DKK	*Bill. '92 DKK*	*Per cent*	*Bill. '92 DKK*	*Per cent*	*Bill.' 92 DKK*	*Per cent*
Real GNP	887.9	-21.4	-2.4	-10.7	-1.2	-8.5	-1.0
Real private consumption	439.3	-16.4	-3.7	-9.2	-2.1	-2.5	-0.6
Real public consumption	229.0	0	0.0	0	0.0	0	0
Real investments	161.0	-3.2	-2.0	-1.3	-0.8	-0.6	-0.4
Real export	324.2	-5.4	-1.7	-0.4	-0.1	-5.7	-1.8
Real import	265.6	-4.8	-1.8	0.7	-0.3	-1.0	0.4
Real capital apparatus			-3.4		-1.4		-0.7
GNP deflator			-1.9		-1.0		0.5
Consumer prices			-1.4		-0.8		0.3
Price of investment goods			-1.9		-0.9		-0.4
Terms of trade			-0.4		-0.2		1.9
Money wages			-3.7		-1.8		-1.1

7.2.2 **Results**

Tables 7.4, 7.5 and 7.6 show the prices deriving from the change in production and the economic consequences.

Big changes in prices

It will be seen from table 7.4 that there are relatively big changes in both prices and export, except in the case of beef and milk, because, as shown in table 7.3, beef production is unchanged in all the scenarios. The biggest change would be in cereals and pork. With 0-import, the supply of grain would be very limited, which would result in a high level of demand and therefore a high price to the farmer (+91%). This would affect both pork and poultry, where it is assumed that the increased demand would result in a price rise of 25-27% ex abattoir.

- and a fall in GNP and

private consumption
It will be seen from table 7.5 that the fall in production with the present yield level would result in a fall in GNP of 2.0-3.0% or DKK 17-26 billion (1992 level). Private consumption would fall by 3.7-5.5% or DKK 16-24 billion, corresponding to DKK 3,100-4,700 per capita per year. With an improved yield level (table 7.6), similar effects would be seen, but they would be much less as a consequence of the small fall in production.

In the scenario in which a change in the preferences of foreign consumers is assumed to benefit Danish organic production (far right-hand column in table 7.6), GNP would be reduced by DKK 8.5 billion. With this willingness to pay among foreign consumers, private consumption would fall, which can be taken as an expression of the welfare-economic consequences, although it would only fall by DKK 2.5 billion, corresponding to DKK 500 per capita per year. A detailed discussion of the results is given in Jacobsen & Frandsen (1999).

7.3 Operational consequences

The structure of farms would change considerably
The structure of farms in the organic scenarios is expected to differ considerably from the structure in present-day Danish farming. Today, most full-time farmers specialise in one particular production – arable farming, pig farming or dairy farming. It is assumed that, with 100% organic production, a more diversified crop rotation would be practised throughout the country, as described in chapter 5, and that manure would be evenly distribution in relation to the crop rotation. That means that the cattle would be spread over the entire country in order to make use of the large quantities of clover grass that are a substantial part of the rotation. At the same time, it is assumed that there would be a number of changes in the livestock housing systems (see section 5.3).

- and the time horizon is therefore 30 years
If implemented over a short span of years, the big change in the structure of farming would have very serious economic consequences for most types of farm because the existing housing for livestock would have to be changed or shut down. This is one of the main reasons for choosing a 30-year time horizon. A time horizon of this length would allow depreciation of the existing livestock production facilities without major extra costs.

Economic consequences for three types of farm
To obtain an indication of how the existing types of farm would be affected economically, (Folkmann 1999a) carried out a comparison of the operating economy of the three main types of farm converted to organic production. In this comparison it is assumed that the specialisation would be maintained. The analyses have been made with conventional prices and without subsidies for organic production. The need of the organic farms for price premiums has then been calculated in such a way as to achieve the same total result at farm level in conventional and organic production. The advantage of this comparison is that it thereby becomes possible to see the products' mutual competitiveness with organic products compared with the present situation, which is important when considering the development perspectives for organic agriculture (see section 9.3). However, it should be stressed that the

general economic framework, as described in section 7.2, is of critical importance to the national economy and therefore also to the operating economy at farm level. Therefore, the results shown in table 7.7 should be seen only as some selected examples.

- show that the need for price premiums

It will be seen that the need for price premiums varies greatly between the different products. There would be least need in the case of milk because dairy farming is the easiest production to adapt to the organic production rules. In the case of pig farming, the analyses apply to an intensive organic farm that imports 25% organic feed, for example from an arable farm. In this situation, a price premium of 46% would be needed for pork, but the premium would have to be twice that size in the case of a self-sufficient farm. In the case of arable farming, the price premium needed would vary slightly between clayey and sandy soil, but would be around 60%.

- is greatest at arable and pig farms

It should also be noted that the EU pays more in hectare support to conventional farmers because organic farms use less land for such crops as cereals and special crops, for which hectare support is provided, and more land for clover grass, which does not qualify for hectare support.

Table 7.7 *Examples of economic results at farm level of restructuring specialised farms. DKK 1,000 per 100 ha* (Folkmann 1999a)

Type of farm		*Total yield (of which EU's ha support)*	*Result Gross margin 2*	*Price premium needed, %*
Arable farm, clayey soil	Conv.	807 (239)	395	-
	Econ.	522 (226)	218	59
Arable farm, sandy soil	Conv.	641 (230)	145	-
	Øko.	428 (226)	7	63
Dairy farm	Conv.	1,797 (157)	106	-
	Econ.	1,622 (129)	-58	13
Pig farm	Conv.	3,381 (247)	470	-
	Econ.	1,900 (165)	-204	46

7.4 Economic valuation of environmental improvements

It has not been possible to quantify the value to society of the effects on health and environment

The purpose of the valuation has been a tentative calculation of the value to society of the environmental improvements that a ban on the use of pesticides or complete restructuring of Danish agriculture for organic production can be expected to produce. The improvements include reduced pesticide and nitrogen pollution, smaller energy consumption, greater biodiversity and recreational and aesthetic benefits.

The valuation studies have not created a basis for a real cost-benefit analysis of a pesticide ban or conversion to organic farming. That is partially due to the fact that the scientific part of the Bichel Committee's work has not generally led to conclusions on which valuation estimates can be based. That applies, for example, in the health sphere, where it has not been possible to arrive at quantified estimates of the health effects of pesticides. In the case of biodiversity and other "soft" values, it has not been possible to find foreign valuation studies sufficiently similar to the scenarios analysed here for unit values found to be used. That leaves three calculations of benefits based on the alternative cost method. The benefits in question are savings to society from reduced energy consumption, savings within water supply with a ban on pesticides and a very rough estimate of the potential savings from reduced nitrogen leaching in the organic scenarios.

- except as alternative costs

An alternative cost analysis covers only the savings to society from future conversion to organic farming in future. Coming losses as a consequence of the "sins of the past" in the form of production practised in the foregoing decades cannot be prevented by changing the form of production in future. In economic terms, it is a question of "sunk costs" (Dubgaard et al. 1999a).

- of pesticides, greenhouse gases and nitrogen pollution
- of the order of magnitude DKK 1-1.5 billion

The calculated economic orders of magnitude are DKK 100 to 200 million a year with discontinuation of the present use of pesticides, calculated as saved prevention measures, DKK 300 to 500 million per year with reduction of the national emission of greenhouse gases, calculated for the organic scenarios in which feed is imported (see section 6.2.2), with the reduction valued as substituted wind energy, and, lastly, DKK ¾billion a year as a consequence of reduced nitrogen pollution. The nitrogen leaching is valued as saved costs in connection with AEP II. However, all the calculations must be treated with great caution because they are encumbered with considerable uncertainty. All in all, these calculations give benefits of the order of magnitude of DKK 1-1.5 billion on an annual basis from restructuring for organic production (Dubgaard et al. 1999a, 1999b, 1999c).

Willingness to pay has not been investigated

As mentioned, there are considerable benefit components that it has not been possible to value. This applies primarily to human health effects and biodiversity. It would not be sound, either, on the present basis to say anything about the order of magnitude of these benefits seen in relation to the calculated loss figures. A complete cost-benefit analysis of the socioeconomic advantages and disadvantages of ceasing to use pesticides/switch to organic farming requires extensive empirical analysis of people's willingness to pay for the "soft" values associated with these scenarios.

7.5 **Discussion**

100% restructuring presupposes "command and control"
- while the market coordinates demand and price
Conversion need not be based only on the market,

The economic analyses have been very much in the nature of a set task: to analyse 100% restructuring for organic agricultural production with an implicit assumption of "command and control". With such an assumption, total restructuring can be envisaged, but the analyses show that the costs would be high. If one instead allowed demand and the price mechanism to govern the rate of conversion via the market, there would be no guarantee as to how much would be converted, but it can be assumed that the conversion that did take place would improve society's welfare. That is because, according to current economic theory, a market-driven change is synonymous both with a more effective resource allocation in society, with the consumers, through their change of preference, individually assigning the "right" value to organic food products, corresponding to their willingness to pay. This assumes, however, that the change is not connected with negative externalities in the form of impairment of the environment or similar. When it is a case of conversion to organic production, it can be assumed that the change would have positive environmental effects. That means that – once again according to current economic theory – conversion would not have to be based on market forces alone in order to improve society's welfare.

- because common goods must be based on government regulation
As far as the health aspects are concerned, it can be held that it is partially a case of private goods. The consumers can choose organic food products produced without pesticides etc. – and pay the necessary price premium. On the other hand, it is difficult to imagine efficient regulation through the market with respect to allocation of such common goods as groundwater and biodiversity. The consumers could admittedly reduce the use of pesticides and nitrogen by buying organic products, but in the case of public goods it is unlikely that voluntary payments would ensure an adequate supply, seen from a societal point of view. That would correspond to basing the production of "classic" public goods, such as law enforcement and military defence, on voluntary payments. The solution is financing through compulsory contributions in the form of taxes and levies. The economic explanation for the need for environment policy instruments in the form of injunctions, bans, environmental taxes, etc. is that externalities are also in the nature of public goods.

The counterpart of taxes on pollution is grants to produce positive externalities, such as increased biodiversity. Therefore, as long as conventional agricultural production must be regarded as more environmentally harmful than organic production, it can be argued that the rate of conversion should not depend solely on the consumers' willingness to pay price premiums for organic products. A societally optimum supply of organic agriculture's total bundle of private and public goods therefore means that the market-driven price premiums must be supplemented by public regulation. Valuation analyses have not provided an exhaustive answer to the question of the societal value of the positive externalities from organic agriculture.

7.6 **Summary and conclusion**

An established market
Today, there is an established market for organic food products. About 3% of all Danish food consumption is organic and the share of the market ranges

from 0-22% for different products. It is characteristic that the highest market shares are gained for relatively cheap food products, such as milk, potatoes and vegetables. For processed products, such as meat, cheese and butter, the market shares are small.

- with price premiums
The price premium also varies greatly – from 5 to 90% for the farmer in relation to corresponding, conventional products. In the longer term, it is estimated that a price premium of 10-25% would have to be paid by the consumers to enable continued growth in the market share of organic food products. However, for a growing market for organic food to materialise, the consumers would have to compose their consumption not only with a view to satisfying their material needs but also with consideration for their own values, including an interest in the production process in food production.

The consequences are difficult to predict
It is extremely difficult to predict the socioeconomic consequences of 100% organic farming because the change is a very big one, with both primary agriculture and a number of associated sectors affected to a greater or lesser extent.

A number of analyses have been carried out with a socioeconomic model that primarily throws light on the socioeconomic costs – consequences that would arise from the fall in primary production. The analyses are based on a "compulsory" switch to organic farming because that would be the only sure way of achieving 100% conversion. Any preferences the Danish consumers may have for organic farming have thus not been valued. On the other hand, a sensitivity analysis has been carried out in which it is assumed that foreign consumers' preferences change to the benefit of Danish organic products.

Impairs the national economy
The socioeconomic analyses show that 100% organic farming in Denmark with unchanged consumer preferences (i.e. without premium prices) would impair the national economy. The gross national product (GNP) would be reduced by 1-3%, corresponding to an annual reduction of DKK 11-26bn. Private consumption would be reduced by 2-5%, corresponding between DKK 1,900 and DKK 4,700 per capita per year.

The reduction is most significant in scenarios without import of feed, and improved yield levels reduce the reduction. The different agricultural sectors would be affected very differently. For example, the cattle sector would remain largely unchanged, whereas the pork and plant sectors would be very badly affected.

- depends on consumer preferences
A sensitivity analysis has also been carried out in which changed consumer preferences in the export markets are assumed, corresponding to a price premium of 10% on milk and 20% on pork. This analysis has only been carried out for 15-25% feed import and improved yield level. The analysis shows that this would reduce private consumption by about DKK 500 per capita per year and that GNP would be reduced by DKK 8.5 billion per year.

Analyses have been carried out of the economic consequences of conversion at farm level. They show that the costs would be relatively greater for the arable and pig farmers than for dairy farmers.

A valuation has also been carried out of the quantifiable environmental benefits of omitting pesticides, reducing nitrogen leaching and reducing emissions of greenhouse gases. There are big differences in the different groups' willingness to pay for environmental benefits, and the valuation here is based only on alternative costs in the form of society's savings in connection with the conversion. The analysis shows that the alternative costs of the environmental benefits can be put at DKK 1-1.5 billion per year, but it should be noted that the valuation is very uncertain.

The market coordinates demand and price
- but welfare improvements can also be based on government regulation
The socioeconomic analyses show that the costs of compulsory 100% conversion are high. If one instead allowed demand and the price mechanism to govern, there would be no guarantee as to how much would be converted, but it can be assumed that the conversion that did take place would improve society's welfare. That is because, according to current economic theory, a market-driven change is synonymous both with a more effective resource allocation in society and with the consumers, through their change of preference, individually assigning the "right" value to organic food products, corresponding to their willingness to pay. Since a switch to organic farming is associated with beneficial environmental effects, it need not be based on market forces alone in order to improve the welfare of society, but can also be based on government regulation.

8 Legal aspects

The Sub-committee on Legislation has looked at legal questions concerning a possible restructuring of Danish agriculture for organic production (Sub-committee on Legislation 1999). The conclusions of the sub-committee are presented below.

Compulsory conversion is hardly feasible with the present EU rules
The first question is whether it would be possible to force through total restructuring of Danish agriculture for organic production by means of national legislation. The sub-committee concludes that it would hardly be possible to do that under the present EU rules. This is primarily because organic production would entail significant restrictions on the use and sale of plant protection products and conventional foodstuffs. Compulsory conversion to organic production would therefore give rise to the same problems as discussed in the sub-committee’s report on reducing the use of pesticides in agriculture (Danish Environmental Protection Agency 1999d). In this connection, WTO law would hardly cause any serious problems beyond those raised by EU law, and there is nothing in the Danish Constitution to prevent compulsory conversion of the kind mentioned.

- and importation of non-organic food products cannot be banned
The second question concerns a possible ban on the importation of non-organic food producs. The sub-committee finds that Denmark cannot unilaterally ban the importation of non-organic food products on account of the rules of EU law on trade.

A "Produced in Denmark" label cannot by introduced by law
The third question concerns labelling of food products. EU rules permit the labelling of food products as being organically produced. If Denmark were to implement such a scheme, however, that scheme would need to be open to manufacturers who satisfy the conditions of Regulation No. 2092/92 in other Member States. Something similar applies with respect to WTO. It is not possible to set a general requirement in Danish legislation on the labelling of Danish food products as being produced in Denmark. On the other hand, the agricultural industries can voluntarily establish such a labelling scheme.

- and it is hardly likely that a purely Danish subsidisation scheme would be approved
The fourth question concerns government subsidisation of organic farming. Current EU rules open the way for subsidies in the form of co-financing of support for organic production, but not for subsidies for compulsory organic production. The rules are at present being revised, but no change is expected on this point. A purely Danish scheme for supporting organic production would require EU approval in pursuance of Articles 92-93 of the European Treaty concerning government subsidies. The sub-committee is of the opinion that it would be difficult to obtain such approval, as this would be a question of subsidisation of an entire industry.

The most realistic option would be voluntary conversion – possibly supported by regulation

The Sub-committee on Legislation has also considered the actual possibilities of promoting conversion to organic production (total restructuring). As long as the present EU rules remain in force, the most realistic option would be voluntary conversion to organic production – possibly supported by tax regulation. The sub-committee also suggests some initiatives the Danish government could take in an EU context – for example, trying to get subsidisation under the EU's agricultural schemes made more dependent than at present on the use of organic methods of production.

9 Discussion and perspectives

Assumptions for the scenarios are parameters that can be discussed
In the foregoing four chapters, 100% restructuring of the agricultural sector for organic production has been described and analysed with respect to agriculture (chapter 5), environment and health (section 6), economics and employment (chapter 7), and legal aspects (chapter 8). The main focus has thus been on agriculture, nature and economics, whereas local, social and institutional aspects have not been considered to the same extent. The analyses show that 100% organic farming would mean a very extensive and radical change in Danish agriculture compared with today – a change that would have major consequences for the derivative industries and the Danish economy. The changes would be so immense that a long time perspective (30 years) and a number of assumptions are necessary simply to be able to describe a coherent 100% organic scenario. The assumptions in question can be regarded as parameters that can be discussed and that will determine whether an organic scenario can be achieved.

The purpose of this section is to focus on the main parameters and, on that basis, discuss the perspectives of organic farming for Danish society.

9.1 Identification and discussion of main parameters

One vital parameter for both the national economy and the impact on the environment is the size and composition of the primary production. The analyses show that milk and beef production could be maintained largely unchanged in a 100% organic scenario. The size of pig and poultry production would depend on the production of grain and the import of feed. Plant production would in all circumstances be considerably reduced as a natural consequence of the big reduction in the use of plant nutrients and plant protection products. The size of the plant production and the size of the import of feed are therefore two very important parameters.

9.1.1 Size of plant production

Plant production depends on
The size of plant production would depend particularly on the following:

- sufficient quantities of manure being available
- the manure being uniformly distributed over the whole country
- importation of potassium fertiliser
- production of sufficient seed of the necessary quality
- technology and productivity

- manure
With the present waste handling and waste treatment technology in Denmark, manure would be the main source of plant nutrients. It is therefore assumed that this resource would be approximately uniformly distributed over the whole country. The amount of manure has a positive effect on plant production, but the supply is relatively low in the scenarios, even with the biggest livestock population (0.9 l.u./hectare). The yield would therefore clearly be limited by the allocation of nitrogen (table 5.5). On the other hand, the environmental impact from nitrogen leaching would be smaller (table 6.1).

- potassium
The analyses also show that potassium could become a yield-limiting nutrient, particularly on coarse, sandy soil and, in the longer term, on other types of soil. It is therefore assumed that a certain amount of potassium could be imported (see section 5.7). According to the current national rules, permission to apply highly soluble potassium fertiliser depends on acceptance of the need by the Danish Plant Directorate, while the cultivation rules of the National Organisation for Organic Farming do not allow such application. The application of sparingly soluble potassium is permitted. It is also assumed that sufficient seed of the necessary quality could be produced.

- and an improved yield level
The importance of technology and productivity is illustrated by means of scenarios with an *improved yield level.* The effect is relatively big and means, for example, that pig and poultry production could be maintained almost unchanged simply with 15-25% import of feed (see table 5.3). One of the arguments for including an improved yield level is that, with 100% organic production, there would be considerably greater focus on and demand for plants than in present-day organic farming, where the main focus is on milk production (see also section 5.2).

9.1.2 **Import of feed**
Import of feed is a vital parameter for maintaining the present livestock production and associated manure in the organic scenarios. The current rules for organic farming permit the use of a certain amount of conventional feed (15% in the case of cattle and 25% in the case of pigs and poultry). There is also already a rather considerable import of organically produced grain.

Livestock production
The agronomic conditions (chapter 5) and the economic analyses (chapter 7) both speak in favour of maintaining livestock production through importation of a suitable quantity of feed. The legal aspects (chapter 8) point in the same direction, whereas some of the environmental and health analyses point in the opposite direction (chapter 6). The present average livestock population in Denmark (0.9 l.u./ha) appears to provide a good basis for establishing a harmonious and diversified organic production.

depends on importing feed
However, there are grounds to expect the present rules for use of conventional feed to be considerably tightened. The Danish need for imported feed with livestock production maintained would in such case have to be fully covered by organically produced imported feed. It has not been clarified how the foreign exporters of organic feed could achieve balance with respect to nutrients so that they would be able to maintain a larger export of organic feed to Denmark in the longer term. It is therefore uncertain whether it would be possible in the long term to maintain the amount of pork exported from 100% organic farms in Denmark (see also section 9.3.1).

and thus on
A significant change in Denmark's livestock population in the event of 100% conversion to organic production would depend particularly on:
- rules

- legislation and rules on self-sufficiency in feed and requirements concerning the proportion of organic feed

- and a market

- a market and the right economic conditions for animal and plant products.

9.1.3 **Consumer preferences**

National economy impaired

The economic analyses show that, with unchanged consumer preferences, restructuring for 100% organic production would impair the national economy in step with the lower primary production. The value of the environmental benefits of a 100% organic agricultural sector – as far as it has been possible to value them in this analysis – would be lower than the cost to society of a total restructuring, assuming unchanged consumer preferences. If, on the other hand, it is assumed that foreign consumers change their preferences to the benefit of Danish organic products, corresponding to price premiums on the export markets of 10% on milk and 20% on pork, the impact on the national economy would be considerably smaller. Danish consumers' preferences, on the other hand, have not been valued in the economic analyses (see section 7.2).

- depending on the consumers' preferences

- based on other values

However, for a change in consumer preferences and a market trend towards more organic farming, the consumers would have to compose their consumption on the basis of other values than purely material ones, including preference for the organic form of production. Studies from 1998 showed a considerable preference for organic products, in that 68% of Danish families were found to be willing to pay more for organic products. Of this percentage, 39% were willing to pay up to 10% more, 18% were willing to pay up to 30% more and 5% were willing to pay right up to 50% more (Ministry of Food, Agriculture and Fisheries 1999).

9.1.4 **Discussion**

A complete assessment of the analyses shows that the main parameters can be broken down into two groups concerning:

Interpretation and form of production

⇕

and preference for organic production

1. the organic form of production, which in turn depends on the interpretation of organic farming’s basic concept, including legislation and rules on imports and self-sufficiency in fertiliser and feed.
2. society’s interest in and the consumers’ preference for the organic form of production.

are related to

The legal and economic analyses show that compulsory conversion implemented by law and/or a general ban on the use of specific ancillary substances is not a realistic option. Restructuring for organic production would thus have to be based on society's interest in, and the consumers' preference for, the organic form of production and organically produced food products. Society's interest would depend on whether organic farming could produce food products in a more sustainable way than conventional farming and the ability of conventional farmers to change their production in a more sustainable direction.

the national economy
The economic analyses in chapter 7 show that society would suffer loss as a consequence of the lower production and productivity. However, the loss would depend on the interpretation of organic farming because that would influence the size of the production. On the other hand, it has been found extremely difficult to value and quantify the environmental benefits. The cost-benefit analysis is therefore encumbered with uncertainty.

- and with the principles on which organic farming is based
A number of analyses have shown that most Danish consumers prefer organic products. There are thus several factors that make it relevant to examine in greater detail how ideas and principles from the philosophy on which the organic movement is based could be used to contribute to a sustainable development of society.

9.2 **The precautionary principle and organic farming**

Organic farming stems from a different perception of nature from conventional farming. The perception of nature and of the relationship between nature and society determines how society makes decisions that have consequences for nature and the environment. This applies particularly to decisions concerning farming, because farmers administer large parts of the countryside. In this connection, the precautionary principle is playing an increasingly vital role.

9.2.1 **Precaution and prevention**
Precautionary principle
The precautionary principle was first used legislatively in 1976 in Germany. According to this principle, our responsibility to future generations dictates that we must preserve the natural foundation for life and avoid irreversible damage to it. The principle is implemented in practice by (translated from Boehmer-Christiansen 1994):
is practised by
- early identification of risks through extensive research
- acting against potential, irreversible damage before having scientific proof
- reducing emissions of pollutants and promoting cleaner technologies.

- prevention of damage
With this principle, the focus is on thinking about how damage to the natural environment can be avoided so that society does not subsequently have to combat the consequences of environmentally and economically inappropriate actions.

Risk and uncertainty
The precautionary principle can be viewed in relation to current economic decision theory, which distinguishes between decisions under risk and under uncertainty. Traditionally, one distinguishes between risk and uncertainty, using risk about outcomes that can be described by a statistical probability distribution and uncertainty about outcomes where the probability is not known – or where the outcome space cannot be delimited. Uncertainty is

thus an expression of the uncertain and unknown consequences that a given decision may have, and that we cannot quantify (for amplification, see Danish Environmental Protection Agency 1999c, Dubgaard & Christensen 1999 and Ingemann 1999a). The precautionary principle must be regarded as an attempt to operationalise this uncertainty.

Risk assessment of pesticides

In the case of pesticides, risk assessment is based mainly on experimental data, the toxicity and other environmentally relevant properties being measured in laboratory conditions, field trials and similar. However, knowledge based on experience from monitoring environment and health has gained increasing importance in the last few years – particularly since the initiation of an extensive groundwater monitoring programme. Even so, approval of new pesticides can only to a very limited extent be based on knowledge gained in that way because there is usually a considerable time span between use of a pesticide and measurable effects in the form of groundwater pollution or illness. (See also Danish Environmental Protection Agency 1999b).

- does not take account of uncertainty and ignorance

From the mid-1990s, the authorities were able to prove that some pesticides occurred in the groundwater. That came as a surprise to many people. The risk assessment on which approval of the pesticides in question had been based did not foresee the possibility of leaching to the groundwater. This example shows that assessing risks on the basis of existing knowledge is not enough to avoid the undesirable consequences that lie concealed in uncertainty and ignorance. It has, for example, since been documented that, even in clayey soil, pesticides can leach relatively quickly down to the groundwater through cracks and fissures from the Ice Age, and a number of research projects have been initiated to remedy the lack of knowledge in this area. It should be noted that it is difficult to relate finds of pesticides in the groundwater to specific uses of land (Danish Environmental Protection Agency 1999b).

- not everything can be investigated

Although the authorisation procedure now requires investigation of a far larger number of risk factors than previously, there will always be some uncertainty in connection with the use of pesticides. For one thing, for financial and ethical reasons, it is not always possible to investigate all physical and biological factors that might affect the behaviour of pesticides in nature and their effect on people. Using animal tests, one can derive statistical probabilities of a rat getting cancer when it is exposed to different dosages of a pesticide. However, to transfer such a result to a risk assessment for humans, one has to make assumptions that cannot be thoroughly tested because experiments with humans are excluded. Furthermore, in principle, there will always be a probability that a given pesticide has effects that cannot be envisaged at all today – the outcome space cannot be delimited. A risk assessment can therefore never be complete – it will always be encumbered with some degree of uncertainty and lack of knowledge.

Zero-value limit as precautionary principle

Up to the present time, Danish policy on pesticide authorisation has included the precautionary principle. A number of substances have thus been banned on the basis of a so-called zero-value limit because they have been detected in the groundwater (Danish Environmental Protection Agency 1999b). The limit value has been set on the principle that the substances are undesirable in the environment rather than on the basis of proven harm to the environment or health. However, it can be held that even using the zero-value limit, there is some uncertainty about the decision because, as mentioned above, it can and often does take a long time from use of a pesticide until it is detected in the groundwater. Some groups thus believe that it is only a question of time and better analytical methods before largely all pesticides are detected in the groundwater. Conversely, other groups assert that the zero-value limit is set arbitrarily, without any relationship with any adverse or possible effects that the substance may have on, for example, yield and farm economy.

When the damage has been done
Owing to the time span between the use of a pesticide and measurable effects in the form of, for example, groundwater pollution, it is usually difficult to return to the original state, when decisions are based on the zero-value limit. The closure of waterworks we see today is due to the sins of the past, and we can do nothing to change them. Future losses as a consequence of earlier use of pesticides cannot be prevented by stopping the use of pesticides today. This also means that the value of banning pesticides in Denmark does not take account of the harmful effects that are on the way and that these harmful effects can therefore not be included in an economic cost-benefit analysis of the consequences of switching to organic farming (Dubgaard 1999a).
- it is not taken into account in the value of a ban

Risky technologies may have unforeseen consequences
A similar example is the use of antibiotic growth promoters in conventional farming up to the present time. The consequences of this use cannot form part of the basis for regulating the use of these substances before they have been proven, and by the time a relationship between growth promoters and the development of resistance in the environment has been established, the resistance has developed. In this connection, Ingemann (1999a) differentiates between *risky technologies* and *error-friendly technologies*, where error-friendly technologies and their external effects are clearer and permit retreat. Another example of a technology that can have unforeseeable and perhaps irreversible effects is the use of genetically modified organisms. And we know that heavy metals can cause irreversible effects in connection with, for example, mineral fertiliser and recirculation of nutrients.

Scientific knowledge is perceived as imperfect information
The choice of policy therefore depends on the decision-maker's assessment of uncertainly determined – and perhaps partially irreversible – harmful effects. As will be seen from Dubgaard and Christensen (1999), empirical research in risk perceptions and behaviour shows that it can be difficult to explain people's assessment of risk factors on the basis of the assumptions concerning rationality used in conventional economic theory. One reason for this may be that people regard scientifically based estimates of the probability of harm as imperfect information. Where that is the case there may be a *safety premium* in the form of willingness to pay to avoid the uncertainty. The safety premium can make a crucial difference to the result of a cost-benefit analysis based on expert estimates of risks and a similar analysis based on people's subjective probabilities. If a safety premium does exist, it

means that complete removal of uncertainty – for example, by completely avoiding the use of pesticides – may be preferable to the reduction of the risk that can be achieved through risk assessments. This may explain the consumers' willingness to pay price premiums for organic food products, even though scientific assessments indicate that the risk of conventional food products is minimal.

In this connection it is relevant, as a supplement to the precautionary principle, to mention the principle of sustainability, which states that sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The consumers' preferences may thus reflect an attitude to uncertainty about risky technologies, since those preferences vary and can cover far more than utility value in the narrow sense of the word. Another approach to economic assessment of the consequences of a major switch to organic farming than the socioeconomic costs is therefore an economic valuation that seeks to measure people's preferences (see, for example, Beckmann et al. 1999).

Preferences cover more than just utility value

The above examples show that when one is talking about nature – about nature's ability to ensure human health and welfare – and the importance of human decisions in that connection, there is a need for theories that can handle uncertainty and ignorance. The precautionary principle also provides grounds for research to increase our knowledge about the consequences of the decisions taken by society, with particular emphasis on the irreversible and unforeseeable changes. For a more detailed discussion of the relationship between the precautionary principle and sustainability, see Ingemann (1999a) and Alrøe (1999). The precautionary principle, our lack of knowledge about nature and the consequences of our actions in relation to nature, and the sustainability principle are all important when setting limits on human impacts on nature through farming. In continuation of this, how different groups of people would set those limits depends on their perception of nature.

-ignorance

is important when limits are being set

9.2.2 **Perception of nature**

Different perceptions of nature

Figure 9.1 illustrates different perceptions of nature. With the perception of nature as robust, it is assumed that almost everything can be substituted with low long-term costs, mainly as a consequence of an anticipated technological development. With the perception of nature as tolerant, it is held, in accordance with, for example the "environmental space" approach, that there are certain limits to how much nature can be exploited, the resources that can be substituted and the extent to which an adverse environmental impact (pollution) can continue without serious consequences. With the perception of nature as fragile, it is held that almost no human activity can be carried on without serious consequences, while the last attitude: "Who cares?", is simply an expression of indifference to nature.

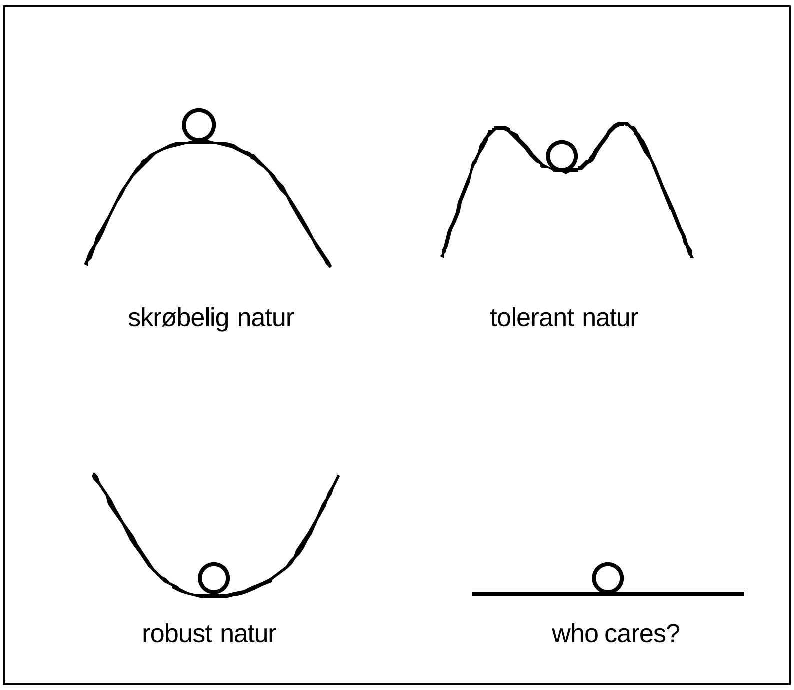


Figure 9.1 *Illustration of different perception of nature* (Arler 1998, based on Schwartz & Thompson).
(Figure text: skrøbelig natur = fragile nature
tolerant natur = tolerant nature
robust natur = robust nature
who cares?

- and limits to intervention in nature
With the different perceptions of nature shown in figure 9, it is obvious that groups with different perceptions of nature will set different limits on man's intervention in nature. At the same time, it should be noted that, although the figure shows fundamentally different perceptions of nature, the perception of nature among different groups in society is constantly changing.

Since the middle of the 1990s, economists have been trying to derive criteria for what can be described as sustainable development. According to Dubgaard et al. (in prep.), the positions today can be divided into varying degrees of "weak" and "strong" perceptions of sustainability. The weakest version corresponds to the robust perception of nature in figure 9.1. It is assumed that it will always be possible to compensate for exhausting natural resources and for environmental impairment with produced capital goods. The sustainability of the development is measured by a single economic indicator: the value of society's total capital, which must not fall over time. The price of this simplicity is an assumption that all natural resources and environmental goods can (easily) be replaced by produced goods.
The robust perception of nature
is simple

- but "mainstream" environmental economists
A modern technological society like Denmark and thus also conventional farming are rooted in the robust perception of nature. However, in the last few years, mainstream environmental economists have shifted away from the

idealised assumption concerning substitutability by introducing sustainability restrictions that require compliance with physically and biologically determined minimum standards.

In a report from 1998, the Economic Council thus differentiates between different types of capital, including natural capital, and sees it as an important task to identify critical lower limits for nature's life-supporting functions – so-called "critical natural capital" (Economic Council 1998). Critical natural capital such as key ecological processes and species must be preserved in order to ensure the stability of ecosystems and the systems' capacity for regeneration. For resources of this type, the principle of economic optimisation must give way to a *precautionary principle.* However, most (mainstream) economists maintain that one must at the same time apply a *proportionality principle* that ensures that the cost to society does not become "unreasonably" big. The economic mainstream has thus moved away from "robust nature" towards "tolerant nature" (figure 9.1).
have moved towards tolerant nature

Ecological economics
and fragile nature
Ecological economists make even greater requirements concerning sustainability. They assume that ecosystems generally develop non-linearly and in discontinuous hops. They also believe that man has already increased economic activity beyond what can be regarded as sustainable in the long term. Under the strong sustainability criterion of ecological economics, economic analysis is subject to ecological principles. The role of economic theory is then reduced to "cost-effectiveness" analyses of different strategies to achieve a predetermined standard for environmental and natural resources. This perception can be said to correspond to "fragile nature" in figure 9.1 or to a "tolerant nature" that comes under too much pressure and thus becomes fragile.

- make it less simple
With the introduction of stronger sustainability assumptions, not only ecological economists but also mainstream economists are approaching ecological science. The "price" is the loss of the weak sustainability principle's analytical simplicity and simple "policy recommendations". That means that prior to an economic analysis of sustainability strategies, one has to set up ecological, technological and ethical assumptions for which economic theory has no scientifically based suggestions. Conversely, the ecological and technological sciences have no suggestions about how general, social prioritisation is to take place. Here, economists can make a contribution in the form of the necessary analytical tools.

With the ecological perception of nature
Organic farming stemmed from the perception of nature as fragile, which gave rise to the original organic movement. Today, however, most of the organic movement has moved towards a perception of nature as tolerant to a varying extent (figure 9.1). The organic farming movement's perception of nature is described in greater detail below on the basis of Action plan II (Ministry of Food, Agriculture and Fisheries 1999). The organic associations in the Nordic countries describe organic farming as follows:

"Organic farming means a self-sufficient and sustainable agro-environmental system in equilibrium. The system is based as far as possible on local, renewable resources. Organic farming builds on an integrated ethos that encompasses the environmental, economic and social aspects in agricultural production both from a local and from a global perspective. Thus, organic farming perceives nature as an entirety that has value in its own right; human beings have a moral duty to steer the course of agriculture so that the cultivated landscape makes a positive contribution to the countryside."

- environmentally foreign substances are not permitted
The use of industrially produced pesticides and other environmentally foreign substances, including genetically modified organisms, is generally not permitted in organic farming. The risk of pesticides occurring in food products, drinking water and the environment can thereby be excluded. This exclusion can be regarded as a different and more far-reaching precautionary principle than risk assessment and the setting of zero-value limits (see section 9.2.1), on which the use of pesticides in conventional farming is based.

Nature constitutes an entirety
The rationale behind organic farming has its foundation in the ecology's view of the interaction between man and nature, which is a central part of the ideology of organic farming. As can be seen from the quote, organic farming is based on a view that nature comprises an entirety to which man is morally obliged to show consideration, both because it has an intrinsic value and because a more self-sufficient agro-ecosystem can be created by using nature's own regulating mechanisms. Agriculture is, in principle, always intervention in the natural ecosystem, but the intervention can be more or less at variance with nature. Soil preparation is thus regarded as a less "unnatural" intervention than the use of environmentally foreign substances. Nature is perceived as a very complex, coherent system, for which reason man does not always have sufficient knowledge to grasp the consequences of various specific actions. Damage to nature and the environment can therefore be ultimately harmful to man.

with man as an integral part of it
The difference from other forms of farming lies mainly in the belief that, for precautionary reasons, one must take a conservative attitude to intervention and changes in the original interaction between nature and man. The reason for this is that we ourselves – or coming generations – could be affected by adverse consequences that we cannot visualise in advance. This is thus an anthropocentric view of our ethical consideration in our interaction with nature that is based on man as an integral part of nature.

- and technology with unforeseeable consequences is rejected
The difference between the attitude of conventional farming and organic farming to the use of, for example, pesticides, growth promoters and genetically modified organisms can be illustrated by two opposing approaches to new technology. One approach is to use a new technology in the first instance in view of the new possibilities and then to limit its use in the event of unforeseen and unacceptable consequences. The other approach is to reject new technology in the first instance in view of the unforeseeable consequences and only to accept its use if further research and development of the technology manage to cast light on the possible consequences.

However, the trend in recent years has shown that society and conventional farmers are also increasingly rejecting new technology in advance. In Denmark and in the EU, the use of growth hormones as a means of stimulating milk production has been rejected.

9.3 Organic farming's possibility of contributing to a sustainable form of food production

The changes in the perception of nature necessitate some amplification of the rationale and basic principles of organic and conventional production. It has been explained in the foregoing sections how the two forms of production originate from different perceptions of nature. In extension of that, it can be argued that the two forms of production are also based on different perceptions of how sustainable agricultural production should be organised.

9.3.1 Sustainability in farming

The American philosopher Paul B. Thompson has written several books on a sustainable development in agriculture and on the perceptions of different groups of a sustainable development. Thompson (1997) argues that there are two basically different perceptions of a sustainable development:

Two fundamental perceptions of sustainability

- resource sufficiency
- functional integrity.

- resource sufficiency and

The basic idea behind "resource sufficiency" is relatively simple, the main focus being on the relationship between input and output in the systems under consideration. This means, for example, that yield should be considered not only in relation to ancillaries, but also in relation to, say, nitrogen leaching and CO_2 emission. The focus is not, on the other hand, on the internal properties of the system itself. The systems that are most productive are thus the most sustainable. This perception has been very dominant in modern, conventional farming.

- functional integrity

The idea behind "functional integrity" is somewhat more complicated, the main focus here being on the system's internal properties, e.g. the system's ability to reproduce itself and to survive in the long term. The basic view is that the system is vulnerable and that there are some fundamental elements in the system that are reproduced over time in a way or at a rate that depends on the condition of the system at an earlier point of time. For example, the genetic properties of livestock and crops determine the next generation of livestock and crops, and the fertility of the soil at a given point of time determines the production of the crops at a later point of time. In functional integrity, the natural environment is generally seen as an inseparable part of society's sustainability.

With its focus on the vulnerability and internal properties of the system, and with its recognition of our limited knowledge, functional integrity has much in common with the perception of nature as fragile. This perception is the basis of at any rate the more original ideas in the organic movement. A detailed analysis of the sustainability concept in connection with organic farming is given in Alrøe & Kristensen (1999).

Resource sufficiency can include environmental impacts

The resource sufficiency line of thought can be seen as an extension of the production and efficiency view that predominated in agriculture until the mid-1980s. The focus is expanded from covering only the product itself to also covering environmental parameters. According to neoclassical economic theory, the so-called externalities (= environmental impacts) can be internalised by means of green taxes, so the production can now be optimised, also taking account of the externalities. The form of production known as "integrated production" and the legislation on nitrogen emission are examples of the resource sufficiency approach. The agricultural sector has also done much on its own initiative to spread the resource sufficiency approach in farming – for example, through the booklet "Good farming year 2000" (Danish Agricultural Advisory Service 1996). The last few years have also seen the start of some advisory and R&D projects that will contribute to a sustainable development in accordance with the resource sufficiency philosophy. All these initiatives will doubtless ensure effective solution of recognised environmental problems while at the same time taking account of production. On the other hand, one cannot, for good reasons, expect account to be taken of as yet unrecognised environmental problems.

In organic farming the focus is on internal properties at the expense of yield

In organic farming and other low input forms of farming, the focus is more on the system's internal properties than on external efficiency. The systems are often less vulnerable because their production is to a great extent based on diversity and internal properties. The lower dependence on external resources and greater focus on the system's own reproducibility increase the system's sustainability as understood in functional integrity. As a consequence of the perception of nature and increased focus on the system's vulnerability, it can be assumed that the system will in itself prevent environmental and health problems. However, the lack of focus on the external effectiveness of the system means that these forms of operation are not necessarily effective from the point of view of resource sufficiency and that the size of the production is typically smaller. This analysis of 100% organic farming indeed shows that production is considerably smaller than in present-day farming (see chapter 5).

Conversion costs in step with the market

All else being equal, the costs per produced unit would therefore be higher with the organic form of production. The increase in costs would be intensified if the rate of restructuring were accelerated beyond the market potential. That is due to the big conversion costs that could arise because of the adaptation of livestock housing systems and the dispersal of livestock production in connection with accelerated conversion. With a market-adjusted rate of conversion, such extra costs could be avoided. Organic food products therefore depend on price premiums or on society's support for the form of production. However, there are limits to the extra cost that can be accepted. In step with increasing conversion to organic production, there would therefore be a growing wish for increased efficiency and more efficient use of resources in organic farming as well. If, at the same time, more knowledge were built up on the basis of organic cultivation principles, it can be assumed that it would become possible to increase efficiency without diminishing the system's functional integrity or abandoning the preventive approach to environmental and health problems.

Both organic and conventional farming are thus working towards a sustainable development, but from different perceptions of the concept of sustainability. The question is now whether the organic methods of production can be made more efficient without abandoning the perception of sustainability on which organic farming is based.

9.3.2 **Challenges for organic farming**

- would be limited or perhaps banned altogether

The use of conventional feed

An example of an area in which there is a need for development, is the requirements concerning the degree of self-sufficiency in feed and manure in organic farming. Today, organic farmers are allowed to use 15% conventionally produced feed for cattle and 25% for pigs and poultry. They are also allowed to purchase up to 25% of the crop-specific nitrogen standard in the form of conventional manure. However, these rules are under discussion and have already been tightened (in 1999), with a 5% reduction in the amount of conventional feed that may be used (to max. 10% and 20%, respectively, of the feed need). At EU level, a proposal has been put forward to ban the use of conventionally produced feed altogether. The rationale behind the tightening of the rules is that it is in practice possible to produce without the use of conventional feed.

The tighter rules are of only minor importance as long as only a small proportion of farms in an area are organic and there is surplus manure in the area. If there were a large proportion of organic farms and there were not surplus manure in the area, other sources of nutrients would be needed in the long term to make up for export and loss of nutrients and maintain a sustainable plant production. The analysis in chapter 5 shows that imported feed would be an important source of nutrients. In principle, it has not been decided whether the imported feed should be organic or conventional feed. The main point is that there must be equilibrium in the long term, and the ideal solution would be a return of the nutrients from towns. In the short term, however, it is hardly realistic to envisage a change in waste treatment in towns, and one can thus discuss what would be the best solution from an organic point of view:

Export and loss of nutrients would have to be made up for in one of several ways

- to buy the nutrients in the form of conventional manure (as suggested by the EU legislation)
- to buy conventionally produced feed
- to buy organically produced feed
- to buy mineral fertiliser.

Other questions of principle

Besides the problem of nutrients (section 9.1.2), the analyses in this report have indicated other questions of principle in a 100% organic agricultural sector:

- should the organic rules be more stringent in Denmark than in other countries, with the possible consequence that the consumers buy, for example, foreign organic apples instead of Danish ones?

- what role could and should conventional production play in the production of seed and breeding stock for organic production?
- how does one assess whether it is acceptable to use specific technologies in organic farming?
- how should one prioritise between the input of manpower, the consumption of fossil fuels and the production of biomass for energy purposes?
- how can organic farming be made more efficient without going against its basic values?

Development of organic farming
-basic principles

- and institutional network
Continued conversion depends on organic farming being able to develop into a more competitive and at the same time sustainable form of production by dealing with the challenges facing it. However, this requires a general debate concerning the rules governing organic cultivation with a view to achieving greater local and global sustainability. Michelsen & Kølster (1998) have analysed different aspects of organic farming. The analysis shows that the organic movement and organic farmers in Denmark cover a very broad spectrum. There is thus a good possibility of a positive development, but also a risk of the basic organic principles being diluted. Ingemann (1999b) has analysed Danish agriculture's institutional network and its potential for organic restructuring. The analysis shows that organic farming is integrated in the institutional network. There is a big potential for coordination in the case of primary and secondary producers and the whole of the technology chain. On the other hand, it is more difficult to discern a similar network in the case of distribution and consumers.

9.3.3 **Development perspectives**

Market-driven conversion and government regulation
It will be seen from section 7.5 that a market-driven conversion can be regarded as relevant and desirable from a direct economic point of view. However, it is at the same time stressed that agriculture's impact on the common environment constitutes a basis for government regulation. In this connection, a politically promoted acceleration of the conversion, using, for example, tax and grant instruments and public procurement policy, can be justified by referring to the positive effects of organic farming. From this it follows that the development perspectives depend both on market economic factors and political decisions.

The development trend for Danish agriculture
This is underlined still further by the fact that, in the last few decades, the whole of Danish agricultural production has been included in an extensive regulatory and support system, which means that the present level of production and the present production methods cannot be taken as an expression of a result of market economic development trends. Similarly, the direction in which the agricultural sector develops in the future is expected to be a result of interaction between market economic factors and agricultural policy regimes. The perspectives therefore depend partly on the development of the market, partly on the initiatives promoted by the Danish agricultural sector's decision-makers in connection with the sector's future development

strategy, and partly on political decisions concerning the agricultural policy of the future, both nationally and internationally.

- is influenced by sustainability and values

Reflection on the future development of organic farming puts the focus on sustainability and similar "soft" values (Abrahamsen & Ingemann 1998 and Ingemann 1999a). These values affect the individual demand for organic food products and political decisions about promoting environmentally sound, animal-friendly production systems through agricultural policy measures. Continued high prioritisation of this focus means that the environmental and animal-ethical effects of organic production methods will increasingly influence both market-based demand and political decisions. That will imply powerful incentives for further development and application of such production systems.

However, it should be remembered here that other environmentally sound, animal-friendly production systems have also been developed, although organic farming is the only one that is based on a clear and internationally recognised concept for which international production, certification and marketing structures have been developed. For this reason it must be assumed that a continued positive trend under the "sustainability" banner will enable continued expansion of organic food production. However, that depends on the organic form of production continuing to develop as an alternative to other forms of agriculture, so that there is a basis for the consumers' preference for organic food products.

- and that can promote organic production

According to Action Plan II, organic production must be developed in step with the wishes of society

At the beginning of February 1999, the Danish Ministry of Food, Agriculture and Fisheries presented a plan for promotion of organic farming in Denmark, the so-called Action Plan II, the title of which is “Økologi i Udvikling”(Developments in Organic Farming). It is thus proposed that the organic form of production be developed in step with society’s needs and wishes. In that connection, consumer demand is regarded as a powerful motivator. There are therefore clear indications that the development is already in progress in Denmark.

Forecast for restructuring 2000, projected to 2008

In Action Plan II, a projection is given for the conversion to organic production up to the year 2002. On the basis of this projection, 300,000 ha will have been converted by the year 2002, with a rate of increase of about 50,000 ha per year. Projecting this trend with the same rate of increase gives 600,000 ha in 2008 converted to organic farming. The action plan also presents an analysis of the potential for restructuring within different types of farming. The analysis shows that the potential converters account for a total of 1,236,000 ha. For one third of these, increased cooperation between different types of farms would be required (Table 9.1). Folkmann (1999b) has investigated the possibilities for conversion to organic production up to the year 2008 and finds a similar potential.

and barriers to conversion

There can, however, be other barriers than purely structural ones to conversion to organic production, such as personal and educational barriers

(Folkmann 1999b). Personal barriers can, for example, arise from different perceptions of nature (cf. section 9.2.2). However, the increasing conversion in recent years has shown that such barriers are not static, and it can therefore be assumed that the trend will gradually overcome them.

Table 9.1 *Acreage at present farms that are potential converters to organic production, with a breakdown between two types of soil (1000 ha)* (based on the Ministry of Food, Agriculture and Fisheries 1999)

	Dairy farms <1.0 l.u./ha	*Dairy farms 1-1.6 l.u./ha*	*Pig farms <0.8 l.u./ha*	*Pig farms 0.8-1.1 l.u./ha*	*Arable farms*	*Total*
Clayey soil	21	50	36	37	227	371
Sandy soil	123	274	66	56	346	865
Total	144	324	102	93	573	1,236

Distribution of potential converters

On the basis of the Action Plan II's forecasts, two scenarios have been set up for possible distributions of converted farms 1998-2008 without assuming structural changes. In the first scenario, it is mainly dairy farms that are converted. It is assumed that there is an equal distribution between the two densities and that, for every ha converted at dairy farms with 1-1.6 l.u./ha, ½ ha from the arable farms is used through farm cooperation (table 9.2). In the second scenario, the conversion of potential converters is assumed to be equally distributed between the three different types of farm (table 9.3).

Table 9.2 *Converted 1998-2008, mainly dairy farms (1000 ha)*

	Dairy farms	*Pig farms*	*Arable farms*	*Total*
Clayey soil	56	0	20	76
Sandy soil	315	0	109	424
Total	371	0	129	500

Table 9.3 *Converted 1998-2008, equally distributed conversion (1000 ha)*

	Dairy farms	*Pig farms*	*Arable farms*	*Total*
Clayey soil	29	30	92	150
Sandy soil	161	49	140	350
Total	189	79	119	500

Further projection of the forecast to 2018

A scenario has also been set up in which Action Plan II's forecasts are projected a further 10 years to 2018, with the same rate of conversion and an equal distribution between potential converters. This gives a total of 1,100,000 ha converted to organic production 20 years hence. This figure is based on an assumption of utilisation of most of the acreage of the present potential converters (table 9.1). Structural changes in connection with the establishment of cooperation between dairy farms and arable farms are also assumed, but not changes in the production of special crops etc. Table 9.4 shows the distribution of the converted farms 1998-2018.

Table 9.4 *Converted 1998-2018, equally distributed conversion (1000 ha)*

	Dairy farms	*Pig farms*	*Arable farms*	*Total*
Clayey soil	57	59	184	300
Sandy soil	321	99	280	700
Total	379	158	464	1000

Effect of the development on the use of pesticides

Continued conversion to organic production would result in a reduction in the average consumption of pesticides. The Sub-committee on Agriculture's report on phasing out the use of pesticides gives the treatment frequency in present production. Table 9.5 in the present report gives the average treatment frequency in different types of farm after the development of conversion to organic production described above. It will be seen that conversion of 500,00 ha up to the year 2008 would result in a reduction of 14-18% in the treatment frequency.

Table 9.5 *Average treatment frequencies (TFI) after a projected conversion to organic production 10 to 20 years hence (according to Danish Environmental Protection Agency.1999a)*

Type of farm	*Present production*			*Converted 1998-2008*				*Converted 1998-2018*	
				Dairy farms first		*Equal distribution*			
	TFI	*Acre-age*	*Live-stock unit*	*Acre-age*	*TFI*	*Acre-age*	*TFI*	*Acre-age*	*TFI*
Clayey soil									
Dairy farms (all types, incl. beef production)	1.8	142	203	71	1.1	29	1.4	57	1.1
Pig farms	2.4	220	264	0	2.4	30	2.1	59	1.8
Arable farming with >10% seed-producing crops	2.6	162	53	0	2.6	0	2.6	0	2.6
Arable farms with >10% sugar beet	3.1	168	58	0	3.1	0	3.1	0	3.1
Arable farms w/o seed-producing crops and sugar beet	2.6	218	29	25	2.4	92	1.5	184	0.4
Other (under 20 ha)	2.5	156	63	0	2.5	0	2.5	0	2.5
Total acreage		*1,063*		*96*		*151*		*300*	
Sandy soil									
Dairy farms under 1.4 l.u. dairy cows/ha	1.3	333	352	310	0.1	161	0.7	322	0.0
Dairy farms >1.4 LU dairy cows/ha	1.2	212	390	0	1.2	0	1.2	0	1.2
Pig farms	2.0	450	556	0	2.0	49	1.8	99	1.6
Arable farming with >10% potatoes	3.4	135	52	0	3.4	0	3.4	0	3.4
Arable farming w/o potatoes	2.3	279	50	94	1.4	140	1.1	279	0.0
Other (under 20 ha)	1.8	148	112	0	1.8	0	1.8	0	1.8
Total acreage		*1.556*		*404*		*350*		*700*	
Treatment frequency, weighted section average [a]	2.37				2.02		1.95		1.53
Reduction in treatment frequency					14 %		18 %		35 %

[a] Including spraying against couch grass, which constitutes an average of 0.2 TFI in crop rotations in present production.

The development is influenced not only by farmers and consumers - but also by a network

However, the development perspectives for organic farming cannot be regarded solely as a question of farmers' desire to convert and consumers' desire for organic products, and it has to be borne in mind that food production is part of an extensive network from soil to table and *vice versa* (Ingemann 1999b). This network comprises the products' route from the farmer's soil, through the processing companies and the wholesalers and retailers, to the consumer's table. It also comprises a wide range of research and development institutions, which provide the necessary technology, and advisory institutions, which ensure that the farmers are informed about the technological and economic possibilities and perspectives.

and consumer confidence is vital - it can be achieved through nearness or certification

Communication

The communication between all these levels is important – and particularly important in the case of organic food products because the consumers must be confident that all levels of the production process proceed in accordance with the requirements for organic production. It has been stated that this confidence can be achieved through nearness or certification. By nearness, we mean that the producers are located physically close to the consumers, and this strategy is therefore assumed to be most suitable for small enterprises. These enterprises can at the same time function as a dynamic, development-oriented underwood that attracts the most motivated and creative producers. Conversely, the large companies can act as "battering rams" on the export markets and form the basis for production of organic products that can directly substitute conventional products. Such companies must primarily base themselves on certification, which means that the consumers' confidence will depend on the effectiveness of the control system. All studies show that there is already great public confidence in the government Ø-label (Organic label) in Denmark (Ministry of Food, Agriculture and Fisheries 1999).

A massive conversion, including making use of the possibilities of reaping the benefits of early establishment on major export markets would require extensive input by the network outlined above, and the players would have to agree on such a strategy and be motivated to pursue it.

The development is also influenced by the international development
Lastly, it should be noted that the development of organic farming will also be influenced by international agricultural and trade policy. In this connection, steps have been taken in the WTO towards uncoupling government subsidisation and volume of production. In the EU debate on agricultural policy, there is a call for discontinuation of surplus production and for subsidisation elements to be linked to rural district development and the promotion of environment-friendly production systems. The analyses in this report show that the organic form of production would result in a fall in primary production (see chapter 5).

- and by subsidisation schemes
The trend in international subsidisation schemes could mean that organic production systems become economically more attractive, both nationally and at farm level – particularly if the organic form of production manages better than it has done so far to use its potential for contributing to the development of rural districts (cf. Michelsen & Kølster 1998). From the point of view of the national economy and the government finances, promoting organic farming through subsidies would not necessarily imply increased expenditure if it were done by reallocating existing agricultural subsidies and if the resulting production resulted in an economic return of the same magnitude as the hitherto subsidised production.

9.4 Summary and conclusion

The organic scenarios used in this report are based on a number of assumptions that can be discussed in connection with the perspectives for organic farming in Denmark. The main assumptions can be divided into two groups, as follows:
Interpretation and form of production

and preference for organic production

1. the organic form of production, which in turn depends on the interpretation of organic farming's basic concept, including legislation and rules on imports and self-sufficiency in fertiliser and feed.
2. society's interest in and the consumers' preference for the organic form of production.

is related to the precautionary principle

The trend in organic production has hitherto been based extensively on changes in consumer preferences to the benefit of organic products. This change in consumer preferences may be connected with a conscious or unconscious use of a preventive or precautionary principle based on the consumers' experiences with the use of new technology in farming.

sustainability

Involvement of the precautionary principle is bound up with a perception of nature as more or less fragile and acceptance of man as an integral part of nature. In the form of the concept "sustainability", this insight has gained a big foothold in the national debate.

and perception of nature

Organic farming is based on a different perception of nature than the one that has dominated in conventional farming. This difference in the perception of nature leads to a different approach to food production and prevention of environmental problems. Seen in this way, organic farming will do more to prevent environmental problems than conventional farming. However, the level of production and productivity are lower. Organic food production would therefore involve higher production costs. However, it is estimated that it would be possible to improve the efficiency of organic farming in the long run. A condition for this is, however, that organic farmers want a development in which the rules are generally up for debate but naturally with proper respect for organic farming's values.

Compulsory restructuring is safe but expensive
a market-driven change is cheap but uncertain

The socioeconomic analyses in section 7 show that the costs of compulsory 100% conversion are high. If one instead allowed demand and the price mechanism to govern the rate of conversion, there would be no guarantee as to how much would be converted, but it can be assumed that the conversion that did take place would improve society's welfare. That is because, according to current economic theory, a market-driven change is synonymous both with a more effective resource allocation in society and with the consumers, through their change of preference, individually assigning the "right" value to organic food products, corresponding to their willingness to pay. Since the change would be linked to beneficial environmental effects, it would not need to be based on market forces alone, to improve society's welfare.

Government regulation and changed subsidy schemes increase conversion

It follows from the above that the impact on the common environment from agriculture constitutes grounds for government regulation and that increasing the rate of conversion may be warranted. In continuation of that, the trends in international agricultural and trade policy will be of importance. For example, the current trends point in the direction of unlinking subsidy and production quantity and towards higher prioritisation of environmental objectives. These perspectives may imply incentives for a continued expansion of organic food production.

As far as the market perspectives are concerned, continued high prioritisation of the environment and animal welfare is presumed to lead to continued growth in the demand for organic food products. The reason why this prioritisation is assumed to be primarily addressed to organic food products is that only organic farming is based on a clear and internationally recognised concept.

if the players agree
All in all, it follows that the development perspectives will depend on market conditions and political decisions. In addition to that, however, it must again be stressed that the development perspectives also depend on whether the relevant players agree on and are motivated for a conversion of the extensive network of companies and institutions of which agriculture is a part.

and reduce the use of pesticides
With respect to society's current desire for a reduction in the use of pesticides, organic farming offers an obvious option. If the development continues as hitherto, about 20% can be expected to have been converted by the year 2008, which will result in a 14-18% reduction in the average treatment frequency compared with present practice. As long as there is a market prepared to pay a price premium for organic products, that will be the socioeconomically cheapest solution.

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