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scenarios for the future development

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- Scenarios for the future development

Brian H. Jacobsen, Niels Madsen and Jens Erik Ørum

Copenhagen 2005

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Preface

The purpose of this report is to present possible impacts of new technology and changes in legislation on the profitability of different types of organic farms. The aim is also to look at both the current and future trends in the organic area in Denmark.

The farm level analyses are carried out as part of a larger project entitled "Economic analyses of the future development of organic farming – effects at the field, farm, sector and macroeconomic level". The project links effects at the field-level with analyses at the farm level. These effects are then used in sector and macroeconomic analyses, which are described in other reports from Food and Resource Economic Institute (Jacobsen, 2005 and Andersen et al., 2005). This gives coherent results from the field to the macroeconomic level regarding changes in technology and legislation.

The project was initiated in the Autumn of the year 2000 and was finished in 2004. The research in this project is a result of cooperation between the Danish Institute of Agricultural Sciences (sub-project 1) and the Food and Resource Economic Institute (sub-project 2-4).

The project was funded by the Directorate for Food, Fisheries and Agro Business under the Danish Ministry of Food, Agriculture and Fisheries. The project is a research project (ECON-ORG) under the Danish Research Centre for Organic Farming (DARCOF).

Senior Researcher Brian H. Jacobsen, Researcher Jens Erik Ørum and Research Assistant Niels A. Madsen have written the report. Senior Consultant Johannes Christensen and advisor Niels Tvedegaard have assisted during the editing process. Researcher Ib Sillebak Kristensen (DIAS) has given valuable comments to chapter 6.

Food and Resource Economic Institute, September 2005

Søren E. Frandsen

Summary

The purpose of this report is to present possible impacts of new technology and changes in legislation on the profitability of different types of organic farms. The aim is also to look at both the current and future trends in the organic area in Denmark. Besides the economic aspects, the report also shows the nutrient surplus for selected organic farms.

Analyses carried out at the Food and Resource Economic Institute (FOI) have previously shown that price premiums of up to 50% on pig meat and 20% on arable farm products is needed to make the organic production profitable. The price premium on cereals and dairy products have in the 1990'ties been higher than required, but in recent years the price premium has dropped, leading to low profitability, especially on arable farms.

The organic farms in Denmark consist mainly of two types of farms, full time dairy farms and part time arable farms. The dairy farms constitute 25% of the farms, 50% of the area and they have 80% of the livestock units. The part-time arable farms constitute 60% of the farms, 28% of the organic area and they have 5% of the livestock units. Previous predictions made by FOI regarding more part-time farms converting to organic farming have been fulfilled, whereas the conversion to organic pig production has been much lower than expected. Both dairy and arable farms are facing new threats as the organic milk production is still much higher than the consumption, and as the profitability on small arable farms is low.

The aim of the project is, therefore, to look at the impact of new technology on the profitability of organic farming. As organic farming in Denmark has experienced legislative changes leading to lower use of imported feedstuffs, it was also an aim to look at the impact of legislative changes, allowing only 100% organic feed, straw and manure.

To analyse this eight case farms were selected as typical organic farms. They consisted of 3 dairy farms, 4 arable farms and 1 pig farm. The area and the production on these case farms were based on interviews with local consultants, but they are not actual farms found in Denmark. The intension was to present the typical future organic farm in terms of size, area and crop rotation. The yields and the machinery on these farms were determined in close co-operation with researchers at Danish Institute of Agricultural Sciences (Bygholm).

The analyses regarding the profit shows on case farms a profit on the dairy and pig farms and a negative result on the arable case farms. This is comparable with net profits found nationally on organic farms in 2002. The capital invested in machinery on case farms is lower than found on actual organic farms due to the optimization procedure used to find the right level of machinery.

The analyses also show that there does not seem to be significant differences in the machinery costs between conventional and organic farms. The analysis is based on 16 organic and 14 conventional study farms, which makes costs comparable. The machinery costs on the case farms are in line with machinery costs on organic study farms, where most farms have costs between 3,000 and 7,000 DKK per ha (100 DKK = 13.4 €).

The impact of new technology is analysed, focusing on the technologies which are found to be available in the near future and where the first trials look promising. The technologies analysed include robotic weeding, band streaming before sowing, use of GPS when applying animal manure and automatic milking using a robot. Both weed management technologies are found to be profitable and to be recommended for further development. The purpose is to remove weeds inside the row. GPS might give some economic benefits, but will be more profitable in a scenario with restrictions on nitrogen use. More trials have to be conducted to determine whether GPS is profitable. Automatic milking is not a technology exclusive to the organic sector. The analyses show that if the capacity is well used it might be profitable. As a whole, the technologies do not seem to have a major impact on the future development in the organic sector as the focus is on relatively specialised crops which cover a small area. For the technologies which can be used more widely, the improvement in income is limited.

The difference between organic production and conventional farming has diminished over recent years as conventional farmers use less pesticide and mineral fertiliser. Furthermore, the European rules for organic farming might change. The possible impact of changes in legislation has, therefore, been analysed. The changes include the following restrictions:

- 100% organic feed (requirement from 2005 on dairy farms)
- 100% organic straw (no import of conventional straw)
- 100% organic manure (no import of conventional manure)

100% organic feed has already been introduced for dairy farms in Denmark, whereas for pig farms it will increase feed costs by 10-17%, but the production will still be profitable. Using 100% organic straw will increase income on arable farms a little and lower the income on livestock farms with few cereal crop areas.

The 100% organic manure scenario will reduce the manure (slurry and farm yard manure) used in the organic sector by approximately 20% and increase the price from 5 to approximately 10 DKK per kg N. The effect is a decrease in application of 10 kg effective N per ha. The analyses show that dairy farms will increase their export and apply less than today, whereas arable farms will only reduce their N application a little.

The loss in income among the arable farms is, in the calculation, almost the same as the gains made by the dairy farms, as the yield reductions are limited. However, in the analyses, it is expected that arable farms already today pay for manure imports, which is often not the case. This implies that the costs for organic arable farms found in this analysis under estimate the actual costs. This will also make it more difficult for conventional farms to export their manure.

Another assumption is that transportation costs are minimal. However, this legislation will imply transportation of manure from livestock intensive areas to arable areas. The total cost of this is roughly estimated at 10-13 million DKK or 700-1,000 DKK per ha for the arable farms in Zealand which receive the manure. Alternatively, the arable farms would have to either have their own livestock or farm without the use of animal manure. The conclusion is that such a legislation will reduce the income on arable farms and increase the income on dairy farms and that it would lead to a change in the regional distribution of farms as livestock and arable farms would have to be located close to each other to reduce transportation costs. For dairy and arable farms located close to each other, such legislation would not necessarily lead to much lower profit for the farms seen as a whole as the animal manure might be utilised better.

Whether the prices for agricultural products could increase in case where they are 100% organic, is questionable and is, therefore, not included in the calculation.

In the last chapter, the nutrient balance is estimated on the case farms in the baseline and with a 100% organic manure scenario. The nutrient balance in the baseline shows a nitrogen surplus of 47-110 kg N per ha. The most difficult input to estimate is the

N-fixation, which varies with yield and application of animal manure. The case farms have a phosphorus (P) surplus of around zero. For potassium (K) some farms have a surplus others a deficit of up to 90 kg K per ha.

In the 100% organic manure scenario, the lower manure application affects the surplus more than the slightly lower yields, leading to lower N-surplus, P deficit and larger K deficit than in the baseline scenario. It should be noted that attempts in terms of applying other P and K sources have not been included.

The final chapter deals with conclusions and perspectives on the future of organic farming at the farm level. For the dairy farms, there needs to be a better balance between production and demand. This will probably lead to a reduction in the amount of milk which is given the price premium by 30-40%. In the case where these farms stop as organic farms they will reduce the organic area by 30,000 ha. The organic area could therefore be reduced to 130,000 ha. With the lower organic area it is not likely that the organic milk production will exceed 10% of the total Danish milk production.

However, it is also likely that farms which stop organic production will continue with an environmentally friendly production not using pesticides and with a limit on the nitrogen application. Many organic farmers have, over the years, come to appreciate this type of production. So although some might change back to conventional farming, they will still use less pesticides than conventional farmers and use the crop rotation more actively in order to reduce N-leaching. A smaller organic dairy sector will make the 100% organic manure scenario more costly as the amount of organic manure is lower.

The small part time arable farms will probably carry on as the main income comes from outside farming. The challenge is to make efficient large arable farms profitable and in order to do so, they will have to be very large and be efficient.

The trend will probably continue away from a subsidy for organic production and towards a subsidy for the environmental benefits. The current subsidy level in Denmark is not likely to be increased and the price premium seems to be declining. This indicates that the organic as well as the conventional farms will have to be more efficient to be profitable.

1. Introduction

1.1. Danish Research on the economics of organic farming at the farm level

The economics of organic farming at the farm level has been analysed in a number of publications from the Food and Resource Economic Institute since the conversion to organic farming started in the late 1980'ties (e.g. Dubgaard & Sørensen, 1988; Rude, 1989 and Overgaard, 1993). The analyses were mainly focused on the dairy sector and the possible income on organic dairy farms as, most of the conversion, not unexpectedly, occurred on this type of enterprise.

In the late 1990'ties, the focus shifted towards the future production possibilities Folkmann and Poulsen (1998) looked closely at the production and economic possibilities for organic productions which were not widely adopted in the mid 1990'ties. The conclusion was that a price premium of around 40-60 % on cereals in different crop rotations was needed to make the organic crop production competitive. The analysis showed, furthermore, that organic milk production was more profitable than conventional dairy farming even with lower price premiums than obtained in the mid-1990'ties. A 100% organic feed requirement and a change towards self sufficiency at the farm level was expected to result in a significant decline in milk yields per cow (over 1,000 l per cow), but the production would still be more profitable than conventional farming. In pork production, a price premium of more than 75% was needed to create a profitable production. A final conclusion was that a requirement of 100% organic feed will significantly reduce the profitability of organic pig production.

Another analysis on the consequences of widespread adaptation of organic farming in Denmark was carried out in 1998 (Wynen, 1998). This research pointed out that sugar beet, grass for seed, oil seed rape and peas would be less frequently adopted in the crop rotation at organic farms compared to conventional farms. The reason being difficulty in replacing the use of pesticides and the very limited market for these organic products. The conclusion was that increases in organic farming would require that the future income on organic farms would exceed the income on conventional arable farms. However, with an increase in organic production, the additional price for organic products will fall, which is why only a conversion of less than 25% of the agricultural land in Denmark would be profitable (Wynen, 1998).

Further research into the economics of organic farming at the farm level was carried out in a project on the "potentiel of organic farming in a sustainable development",

looking especially at the conversion period (Tvedegaard, 1999a; 2000a and 2000b). The model concept named Ø-plan has been further developed and the model has also been used to assist the Ministry of Food in calculations regarding the future subsidy levels. The analysis showed that the required price premium is 15-20% on dairy farms, 40 – 50% on pig farms and 50-60% for arable farms (Christensen and Frandsen, 2001). It was concluded that the current price levels matched the required price premium, except from the cereal production where a price premium of around 100% was observed. The incentive for converting to organic farming should, therefore, be highest among arable farms. It was also concluded that the high price on organic grain experienced around the year 2000 will not last and the price premium would fall to a level where it covers the additional long run cost in organic production.

In another part of the project above, interviews among conventional farmers were used to ascertain the potential for future organic production and to find the main barriers preventing further growth (Kledal, 2000; Christensen, and Frandsen, 2001). It was concluded that 15% of the total area (400,000 ha) has the potential for being converted to organic production before 2008. This is an increase of 9% points measured both in hectares and number of farms. The typical farmer who considered conversion in 1999, had either small/medium size arable farms or he was a young farmer who had bought a pig farm with production facilities that were run down and needed replacing.

1.2. Project background

The previous projects have pointed to a range of areas where more knowledge is needed to calculate the economic implications. The 100% organic feed requirement which has now been implemented in the organic dairy sector, was expected to have implications on the crop rotations and increase the area requirements on the organic farms. The relative high import of organic feed, combined with more restrictive feed requirement, leaded to the prediction that the area with organic crops had to increase by 100,000 ha compared to 1999 to meet the organic feed requirement and eliminate import of organic cereals (Christensen and Frandsen, 2001).

Another research area is the impact of new technology on the production costs and use of labour, especially in relation to the more specialised crops like sugar beet, grass seed and peas where the organic production is limited. With lower production costs, the consumer price could also be reduced, which would increase demands both na-

tionally and internationally. The new technology is also expected to have an impact on the possibilities of increasing the production of vegetables.

The content of this project and the whole DARCOF program is linked to the second organic Action Plan from 1999. In that report, more than 80 recommendations were given on how to improve and increase the organic production (Organic Council, 1999). The need for a higher organic cereal production especially in order to increase the supply of organic food is stressed several times in the report. This deficiency in the 90'ties lead to high prices on organic cereals. Reducing the weeds is time consuming and costly, so new technologies should be promoted. Furthermore, the need for more balance between the different farm types converting to organic farming is stressed.

Legislative changes are another field in which more knowledge has to be gained. As conventional farming is using less pesticides and mineral fertiliser, the difference between conventional farms and organic farms is reduced. One way of differentiating organic products from conventional products would be to impose still stricter requirements on organic farming. These restrictions could consist of a ban on the use of conventional animal manure, conventional feed or conventional straw.

For a number of years there has been a significant overproduction of organic milk in Denmark. Although the price premium has fallen from 40% to just over 15%, the produced organic milk is still much higher than the consumer demands. In the year 2000, 31% of the total production of 416,000 tons organic milk where used in organic products in Denmark (Kledal et al., 2001). A small portion of the remaining part was exported as organic or GMO free products, but most is used in conventional dairy products like cheese and yoghurt and sold domestically. The price premium and the surplus of organic milk is, therefore, in essence a transfer of income from conventional to organic dairy farmers. The transfer has been reduced over in recent years as the price premium has been reduced.

As only around 30% of the organic milk was sold as organic milk in 2003, it is relevant to look at the consequences of a reduction in the price premium in order to reach a better balance between supply and demand. Arla Foods have suggested not paying a price premium for newly bought milk quota. Arla Foods have estimated that they need an excess of 25-30% of organic milk over a whole year to cover the variation in consumption between days in the week and over the year. In having this surplus, they

can avoid consumers not being able to get organic milk on specific days which was a problem in the early 1990'ties.

Finally, organic farming has some environmental benefits as no pesticides are used and the level of nitrogen leaching is lower (33 kg N/ha) than for conventional farms (Jacobsen, 2004). The environmental benefits vary considerably between different types of organic farms as the difference in production structure has an influence on both income and the environmental impact. Recently, subsidies have been more closely linked to the environmental benefits (Tvedegaard, 2002b). This means that conventional farmers not using pesticides and mineral fertiliser would also be able to receive the same subsidy although their production is not organic. The conversion subsidy still requires a change from conventional to organic production.

1.3. The aim of the project

The aim of the overall project is to analyse the future development of organic farming in Denmark from the field, farm, sector and macroeconomic level perspectives. The project will for example, look at new technologies, barriers for conversion and regional aspects.

More specifically the aim of this sub-project covering the farm level is to:

- Analyse the machinery costs and compare with conventional farms
- Analyse the possibilities and costs of using new technologies.
- Analyse economic implications of legislative changes
- Analyse the nutrient-surplus on organic farms

The analysis is carried out as a case farm analysis based on 8 model farms which are expected to have a crop rotation and production similar to the future organic farms.

1.4. The organisation of this report

As an introduction, the current development with respect to organic farming in Denmark is described in chapter two. In that chapter, the Danish organic farms are divided in farm types according to the standard gross margin, which has not been made before. Chapter two also describes the current trends with respect to conversion to organic farming. Chapter three contains a more detailed description of the case farms. The current income (base line) for the case farms is also presented and compared with conventional farms in this chapter. In chapter four and five the implications of new

technologies and legislation on the income of case farms are analysed in more detail. In chapter six the nutrient balance for the case farms are presented and the impact of legislation on the N, P and K balances evaluated. The final chapter summarises the future perspectives for organic farming seen from a farm level perspective.

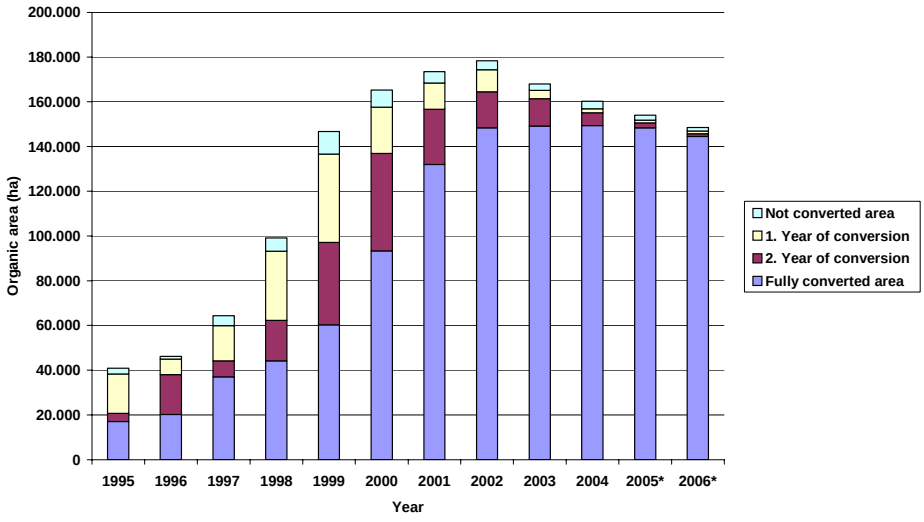
2. Organic farms in Denmark and current trends

2.1. Development in organic area and number of farms in Denmark

The organic area in Denmark increased dramatically in the late 1990'ties from around 20,000 ha in 1994 to 147,000 ha in 1999 (se figure 2.1). The figure includes both area that is fully converted and area under conversion and still farmed conventional on organic farms. The conventional farmed area on organic farms has to be cropped organically within 5 years. In case the farmer has two farms where the production on one farm is organic and the other not, only the area on the organic farm is included in the area shown in figure 2.1 (se also appendix 1).

Also, the number of farms grew rapidly from 600 in 1994 to over 3,500 in 2000 (se figure 2.2). These farms were small farms, but there was also an over representation of farms above 100 ha compared with the distribution among conventional farms. The average size of organic farms in this period increased from 40 ha in 1994 to 48 ha in 2000.

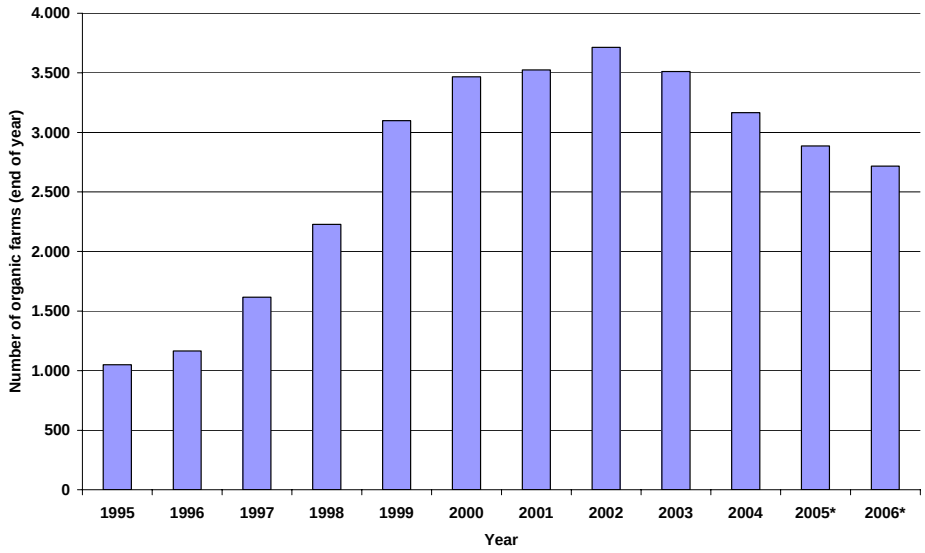
Figure 2.1. Organic area in Denmark (authorizations) 1995-2005



* Preliminary estimate.

Source : The Danish Plant Directorate (2004) and own calculations.

Figure 2.2. The number of organic farms in Denmark 1995 to 2005



* Preliminary estimate.

Source: The Danish Plant Directorate (2004) and own calculations.

The rapid growth in this period led to high expectations with respect to the organic area described in the Action Plan II for organic farming in 1999 (The Organic Council, 1999). An organic area of almost 300,000 ha or 11% of the total area in 2003 was forecasted. The long-term potential of almost 30% of the total agricultural area in Denmark was, at that time, stated as the most likely scenario. However, this forecast disregarded a number of barriers, which will lower the expected area (Kledal, 2000).

In terms of enterprises, the main development in area came from large (over 50 ha) dairy farms situated in the southern part of Jutland. The growth on these farms can primarily be explained by the high milk price and the fact that the conversion only required minor changes to the current production system and crop rotation. Among the small farms, the growth mainly took place in the category of farms with less than 5 ha, which could include farms with organic vegetables like e.g. carrots. The increase in number of other farm types, e.g. full time arable farms and pig farms, was very limited.

After the year 2000, the conversion to organic farming was reduced from over 20,000 ha a year in 1998-2000 to 12,000 ha in 2001 and 7,000 ha in 2002. In this period, more farms stopped organic production. Some farmers experienced falling prices and did not want to farm organically for another five years, which was previously required if they wanted to renew their income support plan. This has now been changed as farmers now get a subsidy for environmental benefits. Hence they do not need the organic authorization, but need only to apply less than 140 kg N and not use pesticides, to receive the subsidy of 870 DKK per hectare. This subsidy is also a 5 year agreement. As the subsidy level is 870 DKK, as opposed to the 600 DKK per hectare given under the old system, many are likely to change to the new subsidy scheme. Furthermore, they have the possibility of getting further environmental subsidy for areas situated in Environmental Sensitive Areas, which has not been possible before.

For 2003, the number of new applicants was only 62, which was the lowest since the beginning of the 90'ties. The number of authorization, which have been ended, constitutes 266, which is the highest number ever. The number of organic farms at the end of 2003 was 3,510. These farms covered an area of 168,022 ha of which 2,876 ha were not fully converted. A total of 149,015 ha were fully converted. It could be noted that crops from approx. 15.990 ha could be sold as crops from an area in conversion.

For 2004, a further drop in the number of organic farms and organic area was expected. The prognoses from the Danish Advisory Centre estimated the reduction to 6,800 ha, reducing the total area to approximately 160,000 ha (DAAS, 2003). The Danish Plant Directorate also estimates that the final level for 2004 will be around 160,000 ha (PD, 2004) covering 3,200 farms.

The farms that convert back to conventional production are large dairy farms with over 100 ha per farm situated in Jutland, but also some small arable farms situated in Jutland (31 ha per farm). Some of the farmers who stop organic production will stop farming and sell their farm, while others convert back to conventional production. However, the increase in area on existing organic farms is estimated to be around 2,500 ha. In total, the expected reduction in the total organic area is 8,000 ha in 2004 (DAAS, 2003). For 2005, a further reduction of 5.200 ha is expected, reducing the total organic area to 155.000 ha (DAAS, 2005). The farms converting to organic production are small arable farms (18 ha per farm), whereas dairy farms (91 ha) and arable farms (40 ha) are giving up the organic production. The total area will then drop to around 5.5% of the total agricultural area, which is still relatively high compared

with other European countries (Offerman and Nieberg, 2002). This trend is expected to continue in 2006.

2.2. Trends in Europe

Organic farming in Europe tripled between 1993 and 1999 and further increases were observed up to 2002 (Häring et al., 2004). Over all, 4% of the agricultural area was farmed organically in 2002. The countries with the highest relative organic area are Austria, Switerland, Sweden, Finland and Denmark. Austria experienced a second wave from 2001 to 2003, bringing the total organic area to 13% of the agricultural area (10% of the farms). The country with the largest amount of hectares farmed organically is Italy. The countries with the lowest organic area in Europe are Ireland and Greece, whereas the growth from 2001 to 2002 was highest in Spain and France. The organic area in the accession countries is relatively low, except in the Czech Republic where the organic area in 2001 was 5%. No other countries in Europe have had the decline in organic area which has been observed in Denmark in recent years.

The conversion rate in Europe, just as in Denmark, has been driven by a combination of high market prices on products and generous subsidies. The analyses made in the year 2000 was based on trends at the end of the 1990'ties (Offerman and Nieberg, 2002). The trends were that organic farms were larger than conventional farms and with a slightly higher labour requirement of 10-20%. The stocking rate is lower and the crop rotation includes more grass and other fodder crops. The yields are significantly lower than in conventional farming and for cereals, they constitute only 60-70% of conventional yields. However, yields in the production of vegetables is on level with yields on conventional farms.

Looking at the price premium, it is higher for milk in Denmark than any other country, but lower for potatoes than in most of the other European countries in the comparison. For all countries surveyed, the milk price premium was between 8 and 36% (Offerman and Nieberg, 2002).

The subsidies given vary between the countries. France and Great Britain only give support in the conversion period (Offerman and Nieberg, 2002). The payment in the first two years of conversion ranged from 100 €/ha/year in the UK up to 470 €/ha/year in Finland and 800 €/ha/year in Switzerland. This can also help to explain the difference in the share of organic farming in these countries. In general, organic farms in Europe in the late 1990's had an income on the same level as conventional farms. In a

number of countries, the average hectare premium to organic farms has decreased since the year 2000.

The outlook in the year 2002 was that the Agenda 2000 reform would increase the competitiveness of organic farming. Furthermore, some countries were intending to increase the subsidy for organic farming. The problem here might be that the demand for organic products cannot follow the supply. It is concluded that the success will depend on whether more consumers are willing to pay the price premium (Hiltrud and Offerman, 2002). Trends for 2004 seem to indicate an overproduction of organic products in some countries.

In a EU project carried out by The Institute of Farm Economics (FAL) in Germany the focus has been the development of the organic sector in relation to the enlargement of EU and the impact of Agenda 2000 (Nieberg et al., 2005). FOI participate in the project as the Danish subcontractor. Preliminary findings with respect to Denmark in relation to the other EU countries show that there are far more organic part time farmers in Denmark and a low average use of labour per farm. The number of dairy cows per farm in Denmark is together with UK and Hungary among the largest in Europe, whereas the organic pig production is relative small.

With respect to future income Danish farmers are, like other western European organic farmers, less optimistic about the future than the current situation. The conclusion is the opposite for the new EU-members (Nieberg et al., 2005). The Danish dairy farmers have a relative high income compared with other EU-countries, whereas the income on arable farms per ha in Denmark is relative low. Finally, it could be noted that the subsidy for organic production constitute an increasing proportion of the net family income from farming in Denmark. However, Danish farmers, which were interviewed, found the support payment as unimportant for the viability of their farm. The explanation is partly the drop in farm family income on organic farms in Denmark, which means that the subsidy will constitute an increasing share of the net profit, whereas it is constantly only 4-5% of the gross farm income. Another explanation might be that many Danish part time farmers have large earnings outside farming and so the subsidy is of smaller importance for the overall income on the farm (Nieberg et al., 2005).

2.3. Reasons behind the current trends in Denmark

In 2001, the price premium on milk was reduced from 20 to 15% despite the introduction of 100 per cent organic feeding requirement for dairy cows (Tvedegaard, 2002b). The more restrictive feeding requirements would increase feeding costs or result in lower milk yields per cow. These initiatives were implemented in order to reduce the organic milk surplus. It should also be noted that not all farmers who would like to deliver organic milk to Arla Foods, were accepted. The total amount of produced organic milk from 636 farms was 425 million kg in 2003. This constituted 10% of all produced milk showing there had been a decline of 7% from the year 2000.

Despite this, it is concluded that organic milk production is still more profitable than conventional milk production until a level of 1.25 livestock units per hectare (Tvedegaard, 2002b). This was also concluded in an earlier study (Folkmann and Poulsen, 1998) although the price of feedstuffs was lower then.

Secondly, the prices on organic crops have been reduced to almost half over a few years. A barley price of 1.60 DKK per kg was expected for the 2002 harvest but only a price of about 1.00 DKK per kg was actually obtained. At this level, the gross margin pr. ha is lower in the organic production compared to the conventional production. For 2004, some organic arable farmers found it difficult to sell their products, as stores of organic cereals were high and the demand limited.

Reductions in crop prices have been forecasted over a number of years, but few had anticipated price reductions of this magnitude. In the late 1990'ties it was assumed that a change towards 100% organic feedstuff requirements in the livestock production would call for an increase in the arable area by 100,000 ha to meet the demands of organic dairy and pig farms.

However, due to increases in farm sizes on existing organic dairy farms and the extended use of feed from area in the second year of conversion, as well as a change on dairy farms towards more widely adoption of grass in their feed rations, the supply of organic grain in 2002 met the demand from e.g. dairy farmers. As the grain companies still had some organic grain from the previous year this has led to significant reductions in the grain price as the export of organic grain was limited. The organic price premium has, therefore, been reduced to less than 50%. The lower grain price reduces the income on arable farms and livestock farms with a low stocking rate, but

improves the income on livestock farms with a higher stocking rate (Tvedegaard, 2002b).

2.4. The Regional distribution of organic production

The organic production in Denmark is mainly found in dairy intensive areas (se table 2.1 and 2.2). The largest concentration of organic farms is, therefore, in the southern and western part of Jutland where the concentration of dairy farms is high. The lowest concentration is on Zealand and Funen. Greater Copenhagen has experienced a growth in recent years, which could be explained by its closeness to the large market in Copenhagen. In all regions other than Greater Copenhagen, West Sealand and Århus, there has been a decrease in the organic area for the past three years. The fall is largest in the Southern part of Jutland both in terms of hectare and relative organic area. This trend continues into 2004 where the largest reduction, are seen in the southern part of Jutland (South Jutland, Ribe and Vejle). (DAAS, 2003).

In total, 71% of the farms and 83% of the organic area is situated in Jutland. The areas under conversion are mainly found in the counties where the growth in the organic area has occurred last. In the County of West Zealand, only 78% of the organic area was fully converted in 2003, whereas the figure for the southern part of Jutland is 90%.

Table 2.1. Organic area in 2003 according to county and total agricultural area

County	Number of organic farms	Organic area (ha)	Average farm (ha)	Organic area in relation to total agricultural area (%)
Greater Copenhagen[1)]	257	10,395	40.4	9.2
West Zealand	278	8,641	31.1	4.5
South Zealand	130	3,487	26.8	1.5
Bornholm	56	1,463	26.1	4.3
Funen	203	4,768	23.5	2.1
South Jutland	458	35,488	77.5	12.7
Ribe	248	14,550	58.7	7.7
Vejle	198	11,303	57.1	6.2
Ringkjøbing	363	24,600	67.8	8.2
Århus	411	18,056	43.9	6.9
Viborg	308	17,259	56.0	6.8
North Jutland	353	18,012	51.0	4.7
Total	3,263	168,022	51.5	6.3

[1)] Greater Copenhagen includes Copenhagen Municaplity, Frederiksborg county and Roskilde county.

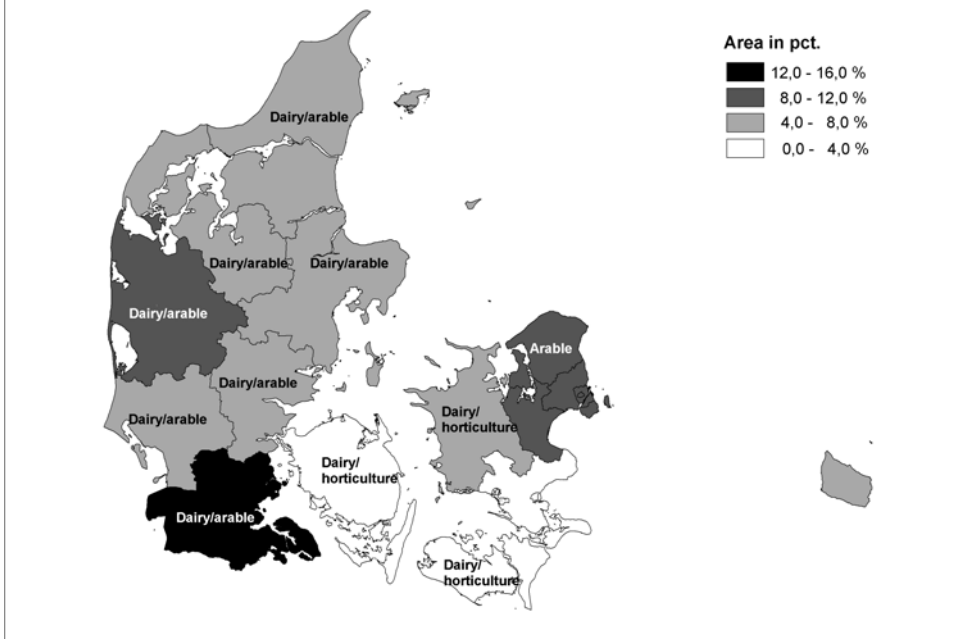
Source: The Danish Plant Directorate (2004).

Typically the farms found in the eastern part of the country are smaller than farms in the western part, as the farms in the eastern part mainly are arable and horticultural farms.

Dairy farms are the dominating organic production in all counties except for the regions around Copenhagen. The arable farms constitute a significant part of the farms in Jutland and especially in the counties of Southern Jutland and Ringkøbing. On Funen and Zealand outside Copenhagen, the second largest type of farms are farms with horticultural production.

The figures from the Food and Resource Economics Institute are representative for all Danish Organic farms above 10 ha. With arable farms (especially part time farms) generating the lowest earnings, it is a question how long this type of farm would wish to convert to organic farming. From a strictly economic point of view, it seems more likely that more professional and larger arable farms would be successful, provided the price premium does not fall well below 50%. A total of 2,262 farms are included in the income statistics from the Research Institute of Food Economics for 2003. This constitute 70% of the 3,263 farms with an authorization in 2003.

Figure 2.3. Main type of organic production and share of area in county in 2003



Source: Food and Resource Economics Institute.

2.5. Organic production on different farm types

Looking at the organic area divided into different farm types, it is clear that although dairy farms constitute only 26% of the farms, they cultivate 46% of the area. The definition of farms is based on the standard gross margin (FOI, and Statistics Denmark). Arable farms, on the other hand, constitute 55% of all farms, but only 38% of the total area. As expected, dairy cows are almost entirely found on dairy farms, whereas sows are primarily found on mixed farms. This indicates that the pig production on many farms are not their primary production, as less than 2/3 of the standard gross margin comes from this enterprise. The number of poultry/pig farms is limited especially in terms of area. Cattle farms are the third largest enterprise, both in terms of number of farms and area. The cattle farms follow the definition in the Account Statistics from FOI. The livestock intensity on these cattle farms is 0.7 Livestock Unit (LU) per hectare, whereas the intensity on arable farms is 0.2 LU per hectare.

It should be noted that the distribution on farm types today is almost identical with the figures from 1998/99, with a small increase in arable and horticulture and a minor decline in dairy farms, as expected (Christensen and Frandsen, 2001).

Of the 94,000 organic livestock units (LU), almost 80% are found on dairy farms. The average stocking rate on all organic farms is 0.8 LU per hectare and on the livestock farms, it is almost 1.2 LU per hectare.

In other publications it has been estimated that 5% of the total organic area is situated on pig farms (Hermansen, 2000). One reason for the difference in estimates is the relatively few farms with other livestock than dairy cows and the use of different definitions. Danish Statistics show, in their calculations, that 40% of all organic farms are dairy farms and that 3% of all livestock units are situated on pig farms. Danish Statistics define, in their environmental statistics, a dairy farm as a farm with more than 2/3 of the livestock units as dairy cows, and an arable farm is defined as a farm with less than 0.5 LU per hectare.

The representation shown in table 2.2 is based on a definition used by Food and Resource Economics Institute where more than 2/3 of the standard gross margin comes from dairy farming. It is to be expected that Danish Statistics, in the future also will define the organic farms according to the standard gross margin. The consequence of the difference in definitions seems to be that the share of arable farms is lower (45%) in the results published by Danish Statistics (2004) where as the results from FOI are 55%. The number of dairy farms is approximately the same in the two calculations.

Approximately 60% of the organic farms were part time farms in 2003, with annual working hours less than 1,665 standard working hours (se table 2.3). These farms cultivate only 29 ha on average per farm and keep very few dairy cows and sows. Although part time organic farms constitute 60% of the number of farms they have under 30% of the organically cropped area and only 7% of the organic livestock.

Table 2.2. Organic farms and area, number of dairy cows and sows in Denmark 2003 (fully converted)

	Number of farms	Share of farms (%)	Area per farm (ha)	Total area (ha)	Share of organic area (%)	Dairy cows (%)[2)]	Sows (%)[2)]	LU (%)[2)]
Dairy farms	525	26	112	58,956	46	94	1	79
Cattle farms	277	14	58	16,140	13	5		9
Arable farms [1)]	1.124	55	43	48,556	38	0	3	6
Poultry and pig farms	31	2	25	768	1	1	20	3
Other farms	83	4	44	3,660	3	0	75	3
Total	2.040	100	63	128,081	100	100	100	100

[1)] Some of the arable farms are farms where more than 1/3 of the standard gross margin comes from cropping and more than 1/3 of the standard gross margin comes from horticulture or orchard/nursery.
[2)] The total number of organic livestock constitutes 55,200 cows, 4,700 sows and 106,700 LU.

Source: (FOI, 2004).

Table 2.3. Organic part- and fulltime organic farms in 2003 (fully converted area)

	Number of farms	Share of farms (%)	Area per farm (ha)	Total area (ha)	Share of organic area (%)	Dairy cows (%)	Sows (%)	DE (%)
Full time farms	820	40	113	93,480	72	100	80	93
Part time farms	1,220	60	29	35,040	28	0	20	7
Total	2,040	100	63	128,520	100	100	100	100

Source: FOI (2004).

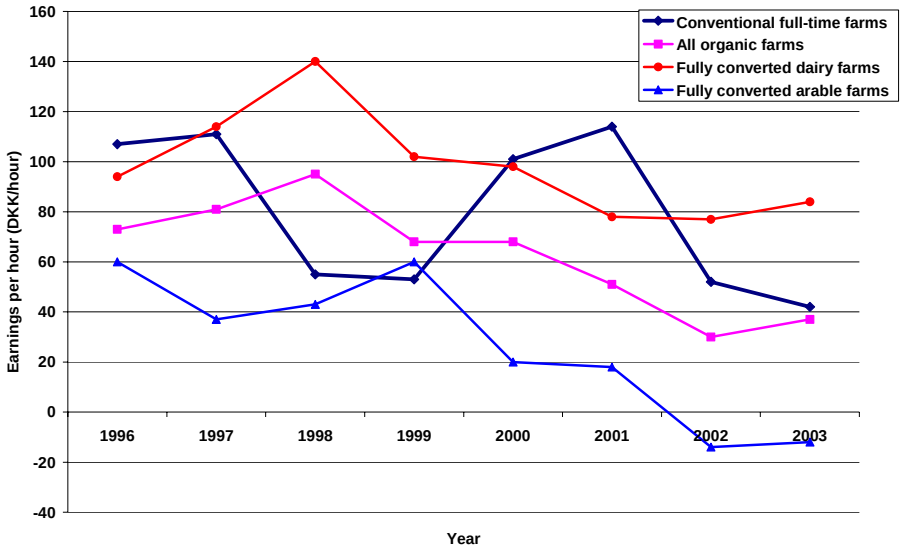
Compared with the conventional production, the Danish organic sector have a larger share of the production in Jutland and an overrepresentation of larger farms (over 100 ha) and small farms (under 5 ha). The share of pigs is only 3% compared to 15% for all farms.

2.6. Income on organic farms

Organic farms typically receive higher prices and larger subsidies than conventional farms to compensate for the lower yields which are typically found on organic farms. Food and Resource Economics Institute has since 1996/97 prepared an annual income statement for organic farms. The income calculated as the income per working hour is shown in figure 2.4. In the period 1996 to 2003 there has been a general decline in

earnings per hour on organic farms as well as conventional farms. In this calculation, capital has been paid an interest of 4%. The earnings are calculated as the remaining profit plus paid salary divided by the total number of working hours.

Figure 2.4. Earnings per hour after interest payment on all capital



Source: Food and Resource Economic Institute (2002-2004) and SJFI (1999-2001).

Other key points from the statistics include:

1. The income level on the average organic farm is slightly lower than the average full-time conventional farms due to the enterprise mix.
2. The income level is slightly higher on organic farms (arable and dairy farms) than conventional farms with the same production structure (enterprise, size etc.).
3. Part time organic farms and especially arable farms have negative earnings per hour.
4. Almost all arable farms are part time farms, whereas most dairy farms are full time farms.
5. The group of arable farms also consists of farms with horticulture growing vegetables etc., which have a higher income than arable farms without horticulture. The average earnings per how on arable farms without horticultural production are negative.

As can be seen from table 2.4, organic farming has clear signs of economics of size in relation to the number of work units. In general, part time farms have negative earnings from the farm, but large income from outside the farm. Full time farms have significantly higher earnings per hour than part time farms.

Table 2.4. Earnings per hour in 2003 on fully converted organic farms related to size

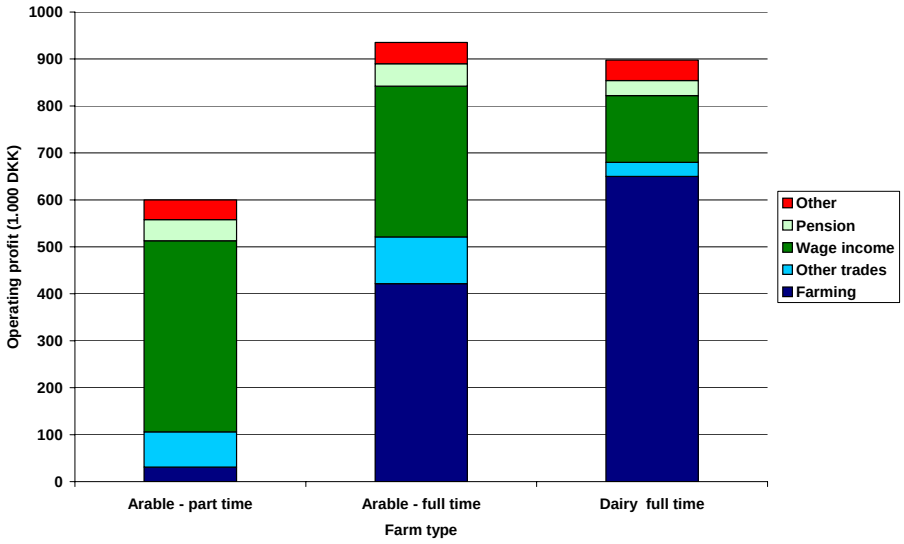
Annual work units[4]	< 1.0	1.0 – 1.9	2.0 – 2.9	> 3.0	All
All organic farms	-74	16	71	121	43
Fully converted dairy farms[1]	----	43	96	106	84
Fully converted arable farms[3]	-79	66[2]	66[2]	----	-12

1) Dairy farms are in the statistics divided into three groups of farms with less than 80 dairy cows, 80-120 dairy cows and over 120 dairy cows. All dairy farms are full time farms.
2) Arable farms with an annual workload of more than 1.0 work unit (1,665 hrs. yearly).
3) In this case arable farms include farms with some horticulture.
4) One work unit is 1,665 standard working hours.

Source: FOI (2004).

The income statistics illustrate that farms under conversion have lower earnings than farms which are converted. With respect to dependence of the income from the organic production, figure 2.5 shows that dairy farms are very dependent on the agricultural income, whereas arable farms have a large income from other sources outside farming. Of the operating profit, dairy farms get 72% from farming while part-time and full-time arable farms only receive 5% and 45% respectively from farming. The conclusion is, therefore, that for the largest group of organic farms, namely the part time arable farms, the income from farming is of no major importance for the total household income.

Figure 2.5. Operating profits from farming and income from outside farming on organic dairy and arable farms in 2003



Source: FOI (2004).

2.7. Has the development been according to previous predictions?

A study into the future potential organic farmers was carried out in 1999/2000 (Kledahl, 2000). The conclusions were that 15% of all farms and all farmland could potentially be converted to organic farming within the next 10 years. Of the expected increase, half was from arable farms and 1/3 from pig farms. Divided into work intensity, around 70% of the potential organic arable and pig farms would be part time farms. Almost four out of five farms were expected to be situated on sandy soil. Finally, it was clear that a livestock density of around 1 LU per hectare (one Livestock Unit = 100 kg N ab storage) is typical for the pig farms considering conversion to organic production. It was also concluded that some of the future organic arable farms have previously been conventional pig farms, but as the production facilities no longer are up-to-date, a change to organic production is less costly, based on an opportunity cost approach. In short detail the growth in the organic sector was predicted to arise from:

- Part time arable farms with less than 30 hectares

- Pig farms with a livestock density around 1.0

The question now is whether the predictions from 1999/2000 are in line with the development until today?

By comparing the organic farms in 1999 and the organic farms converting in 2000 to 2003, the above question has been answered. The results show that almost 60 pct of the growth in organic farms come from part time arable farms with less than 30 hectare. The analysis also shows a decline in the number of dairy farms in Jutland. The relative decline in dairy farms is largest in Vejle, Viborg and South Jutland County.

Among pig farmers, there is a decline among part time producers on Zealand, while there is a small increase in the number of full time pig farms in Jutland. The largest increase is in Århus County with an increase of 7 farms with 50 to 200 ha. The increase has not nearly been as strong as anticipated.

The Counties in Jutland have so far experienced most of the expansion in organic farming in Denmark. The analysis indicates that the largest decline in the different farm types also occurs in Jutland.

The conclusion is that the predictions, made in 1999/2000 based on questionnaires sent to farmers in Vejle County, are in line with the actual development, which has occurred until 2003 with respect to arable farms. For the pig farms the conversion rate has been much lower than expected.

2.8. The future perspective

The total picture of the present conversion to organic farming indicates a decrease in the number of dairy farms and status quo or decline for the numbers of arable farms. This implies a decrease in the total area and a further decrease in the production of organic milk. However, over 60% of the organic producers renewing their subsidy scheme, have chosen to continue. The new scheme, where the subsidy is linked to the environmental benefit, will be hopefully more flexible.

The recent changes have been brought about for two main reasons. Firstly, the amount of organic milk produced today is almost three times as large as the consumption of organic milk. These will continue to put pressure on the milk prices paid to organic farmers. Arla Foods have stated that they hope to reach a utilisation of organic

milk in organic products of about 70-75%. An interesting twist is that the Danish/Swedish milk company Arla Foods in 2005 can not get enough organic milk from Sweden to satisfy Swedish Customers. An export of organic milk from Denmark to Sweden is not easy as Swedish consumers prefer organic milk from Sweden.

Secondly, the reduction in cereal prices has further reduced the income on arable farms, both organic and conventional. There is no sign of large changes which would again increase the organic cereal prices significantly. The reduction in grain prices over the past years has had a negative influence on the profitability of these farms.

The farms converting to organic production are mainly part-time arable farms with an area of less than 40 ha. This is also the prognoses for 2005 from the Danish Advisory Centre (DAAS, 2004). This is also the category with negative earnings per hour in 2003. In other words, the category where there is a potential is also where the prospect of financial success seems minimal. They might benefit from a technological change which would reduce the workload. As previously discussed, quite a few of these part time arable farms convert back to conventional production if the workload on the farm is too high when combined with a full time job outside the farm. Finally, there might be a potential for pig farms to convert if the conditions were right. This requires a larger continuous demand for organic pig meat than seen in the last few years and a guarantied price for a number of years. Increased advertising has increased, the demand for some products in periods, but no schemes for guarantied prices to producers have been suggested as yet.

The overall picture of the organic farm structure is, hence, large dairy farms and small part time arable farms. This is the trend in future organic farms which has formed the focal point of the design of the case farms in this project. In the next chapter these case farms are described in more detail.

3. Organic Case farms

As described in the previous chapter, the development within the organic primary production is likely to come from part time arable farms and to some extent pig farms. Dairy farming will still constitute a large share of the organic area.

These tendencies were confirmed by Danish Agricultural Advisory Service, National Centre in Skejby and local organic advisers from the southern part of Jutland in 2001. In cooperation with the advisers, some farms containing the future organic farms were pointed out. By interviewing the farmers about their crop rotation and production systems, eight case-farms were set up. The purpose of this procedure was to encounter the dynamic and structural changes in the organic sector to ensure realistic case farms. It has been the intention that the case-farms constitute the organic producers of the future with respect to farm size and production systems, but they are not actual farms.

Based on these considerations, the Danish Institute of Agricultural Science and Food and Resource Economics Institute has constructed the eight case-farms. Of these four farms are arable farms, of which one is with beef cattle and another grows vegetables. Moreover three dairy farms and one pig farm is encountered (Nielsen et al., 2003). The farms are described in more detail in table 3.1.

On arable farm 1, the crop rotation consists of 10 hectare grass with spring barley as well as five hectare each of ryegrass for seed and clover grass which is undersown. The ryegrass seeded as under sown the previous year is harvested in field two while the clover grass is left fallow. In the third and fourth field, oats with green crop (under sown) and potatoes are grown. Peas and triticale with green crop is cropped in field five and six respectively.

Table 3.1. Crop rotation and livestock on case farms

	Arable-1	Arable-2	Arable-3	Arable-4	Dairy-1	Dairy-2	Dairy-3	Pig-1
Area (ha)	60	60	50	60	120	150	90	60
Dairy cows (no.)	--	--	--	--	75	110	93	-
Sows (no.)	--	--	--	--	--	--	--	70
Beef cattle (no.)	--	--	10	--	--	--	--	-
Pigs for slaughter (no.)								1400
Crop rotation:								
Field 1	Spring barley	Barley/ Peas	Spring barley/ peas	Spring barley	Spring barley/ peas	Catch Crop	Spring barley /peas	Spring barley
Field 2	Rye-grass for seed/ clover	Lucerne	Oats	Rye-grass for seed	1 year-Clower (grazing)	1 year-Clower (silage)	Spring barley /peas	Clower
Field 3	Oats with catch crop	Lucerne	Spring wheat	Oats with catch crop	2 year-Clower (silage)	2 year Clower (grazing)	Clower (grazing)	Oats
Field 4	Potatoes	Winter-wheat	Triticale	Pota-toes/ beet/ carrots	3 year Clower (grazing)	3 year Clower (grazing)	Clower (silage)	Spring barley
Field 5	Field peas		Maize	Field peas	Spring barley		2. year clower (grass-ing)	Maize
Field 6	Triticale with catch crops			Triticale with catch crop	Maize		2. year clower (grass-ing)	Lupins

Note: In most cases the fields have been divided evenly on the farm area.

Source: Nielsen *et al.* (2003) and own descriptions.

The Danish Institute of Agricultural Science has specified all field operations. The information contains detailed data of where, when, for how long and with what kind of machinery the operation is carried out. In the livestock production, the information is less detailed (Nielsen *et al.* 2003).

The machinery at the case-farms is specified as used but well maintained machinery by the Danish Institute of Agricultural Science. The machinery is defined with respect to the assumption that the farmers wish to carry out as many field operations as possible. Contractors carry out more expensive operations as the machinery is defined with respect to the needs of the case-farm and the economic outcome.

The use of straw depends on the type of farm. At the arable farms the straw is made into bales only if the crop contains under seed, otherwise it is ploughed in. At the livestock producing farms, on the other hand, the amount of straw needed as feed or bedding is pressed into bales. Since every crop is harvested before ripeness at the dairy farm no. 3, the straw is imported from a neighbour.

The productivity in the livestock production is mainly based on DAAS (2001). The production of milk is 7,800 kilo per cow a year at the three dairy farms. At the pig farm, the production of piglets is 20 per sow a year and the piglets are removed from the sow at an age of seven weeks (25-30 kg).

At each of the case-farms a considerable amount of manure is used. In table 3.2, the production of liquid and solid manure and the import of liquid manure are presented. The main part of the case-farms import 520 to 940 metric ton of manure while dairy farm 3 and the pig farm export 78 and 250 metric ton of manure respectively. The large production and the considerable fixation of nitrogen, makes these farms able to export manure in the baseline scenario.

Table 3.2. Own production of both solid and liquid manure and the import of liquid manure

Farm	Own production (ab storage) Liquid, ton	Solid, ton	Import Liquid, tons
Arable farm 1			810
Arable farm 2			520
Arable farm 3		151	530
Arable farm 4			677
Dairy farm 1	1,415	30	940
Dairy farm 2	2,085	44	805
Dairy farm 3	1,764	37	-78
Pig farm	819	30	-250

Source: Madsen & Ørum (2003a+b).

3.1. Use of machinery, equipment and labour

In the following section, the use of resources like machinery, equipment and labour is described for each crop and livestock production as well as for the case-farm as a whole. A work profile for each case farm covering the whole year can be found in Nielsen et al. (2003).

In the field the use of labour differ, a lot between the case farms. The use of these resources is, in general, highest at the arable farms producing vegetables, while lowest at dairy farm 3 (see table 3.3). This is because the crop rotation include only crops for silage making and therefore is better suited for contractors. If the use of contractor, is included then the labour use at dairy farm 3 is almost the same as the other dairy farms. The resources used are lower as a result of the higher capacities of the machinery used by the contractor compared to the equivalent machinery at dairy farm 1 and 2.

Despite the minor differences in the crop rotation between arable farm 1 and 4, the difference in use of resources is striking. The substitution of 5 hectare of potatoes with 4 hectare of sugar beet and a single hectare of carrots diminish as the use of both machinery and equipment, while increasing the use of labour by approximately 500 hours a year. Beets and carrots are due to manual weeding, more labour demanding than potato growing.

The use of labour for milking varies from 1.6 full-time employees at dairy farm 1 to a bit more than 2 full time employees at dairy farm 2. Regardless of the very limited herd of suckle cows and steers the input of labour is 580 hours a year at arable farm 3. As a consequence of having the sows breeding outside using open and small cabins, the use of machinery and equipment is very high at the pig farm compared to the other case-farms. It might be a surprise that the input of labour at the pig farm is almost as extensive as the workload related to the 93 dairy cows at dairy farm 3, but this is a result of the more labour intensive production processes in the open when the labour use is estimated to 36 hrs per sow including pigs for slaughter. As can be seen from table 3.3 the input of labour at the pig farm is only exceeded by dairy farm 2. The intensive use of machinery and equipment in the livestock production at the pig farm makes this case-farm the most machinery and equipment consuming farm.

Table 3.3. The use of machinery, equipment and labour at farm level

	Resources, hours per year		
Farm	Machinery	Equipment	Labour
Dairy farm 1	609	854	3,350
Dairy farm 2	947	1,190	4,400
Dairy farm 3	338	565	3,270
Arable farm 1	647	871	1,290
Arable farm 2	229	211	344
Arable farm 3	327	345	1,110
Arable farm 4	625	763	1,800
Pig farm	1,930	1,930	3,630

Source: Madsen (2003).

Among the arable farms, the workload varies from 344 to 1,800 hour per year, a variation equivalent to approximately 0.8 full time workers. The specialised crop rotation at arable farm 1 and 4 makes these farms the most labour intensive among the arable farms. Sugar beet and carrots at arable farm 4 are is the only difference between the two case-farms. This difference constitutes 510 hours per year. The workload at arable farm 3 is due to the cattle, a lot more labour intensive than arable farm 2. Based on the standard definitions, arable farms 1 to 3 are part time farms.

3.2. Machinery costs

From table 3.4, the average machinery cost per hectare can be seen. The contractor costs differ despite the very similar strategy when it comes to machinery and field operations. Since the farmer on dairy farm 3 hardly carries out any field operations himself, the cost of contracting exceeds the level on the other case-farms. The production of silage at the livestock producing farms and vegetables at arable farm 1 to 4 contributes to relative high costs with respect to contracting. At arable farm 2, the use of a contractor is very limited and despite the related expenditure, is very low.

The very labour intensive production of vegetables results in wage costs of 2,090 DKK per hectare at arable farm 1 and 3,430 DKK per hectare at arable farm 4, while the costs at the other case-farms vary from 173 to 1,060 DKK per hectare. The spending on labour at arable farm 3 is relative high because of the low capacity of the machinery.

Table 3.4. Average machinery cost at the case-farms in DKK per hectare

Farm	Area (ha)	Contractor (DKK/ha)	Value (DKK/ ha)	Depreciation and interest (DKK/ha)	Total cost pr. Ha (DKK/ha)
Dairy farm 1	120	1,690	4,960	550	3,050
Dairy farm 2	150	1,500	7,550	872	3,300
Dairy farm 3	90	2,770	828	90	3,050
Arable farm 1	60	1,620	20,720	2,300	6,510
Arable farm 2	60	327	13,990	1,600	2,750
Arable farm 3	50	2,070	9,240	980	4,430
Arable farm 4	60	1,400	21,120	2,340	7,000
Pig farm	60	1,710	6,190	631	3,550

Note: Total costs are exclusive of shelter and management.

Source: Madsen (2003).

The need for specialized machinery and equipment when growing carrots, beets and potatoes, makes depreciation and interest expenditures very high at arable farm 1 and 4. As a result of the high wage, depreciation and interest cost, these two case-farms face the highest total cost as well. A total cost of 6,500 - 7,000 DKK per hectare at arable farm 1 and 4 is 3,000 - 4,000 DKK per hectare more than the rest of the case-farms. The total cost at dairy farm 3 is lower than at dairy farm 2. Mainly due to the machine strategy.

Based on the machinery costs analysis carried out, there does not seem to be a significant difference in machinery costs on conventional and organic dairy farms (Madsen, 2003). The analysis is based on cost comparisons between 16 organic and 14 conventional dairy farms. They are all study-farms which is why the data is easily comparable.

Extensive comparison of the machinery cost on the case farms at the crop level shows only few possibilities of reducing the machinery cost by optimising the use of contractors. The cost of letting a contractor carry out a single or more operations is in this case defined as the alternative cost. Despite the high level of cost efficiency, it is possible to improve the economic outcome by adjusting the machinery and equipment. The net profit at dairy farm 2, arable farm 1, 2 and 4 can be increased by 22,700, 8,610, 5,840 and 11,900 DKK a year by letting the contractor carry out operations like rolling (Dairy farm 1, arable farm 1 and 4), harvesting (dairy farm 2 and arable farm 2) and potato planting and ridging (arable farm 1 and 4).

3.3. Costs and net profit

Both the total revenue and the costs vary a lot between the eight case farms (see table 3.5). The variation in the average machinery cost is enlarged due to differences in the acreage at the case-farms. Although arable farm 1 and 4 are cultivating 30 hectare less than dairy farm 3, the revenue is 65,000 DKK and 46,000 DKK higher as a result of the specialized crop rotation. Due to higher costs, arable farm 1 has the same profit as dairy farm 3. By comparing the figures in table 3.5, it is noticeable that growing carrots (arable farm 4) instead of potatoes (arable farm 1) does not contribute positively to the net profit.

Table 3.5. Total cost, revenue and net profit in the crop production (1,000 DKK)

Farm	Revenue	Total cost	Net profit
Dairy farm 1	833	847	-14
Dairy farm 2	1,090	1,100	-5
Dairy farm 3	600	618	-18
Arable farm 1	665	674	-10
Arable farm 2	364	398	-33
Arable farm 3	389	423	-33
Arable farm 4	646	709	-63
Pig farm	537	459	78

Source: Madsen (2003).

The poorer financial outcome at dairy farm 3 compared with the other dairy farms is due to a smaller proportion of so-called reform-crops and thereby lower subsidies. In general, the crop production is not profitable except at the pig farm. The pig farm has a net profit of 78,000 DKK while the outcome at the rest of the case-farms varies from -5,000 to -63,000 DKK.

In the livestock production, most of the farms are generating a positive net profit. From table 3.6, it appears that only arable farm 3 is making a loss of 154,000 DKK while the net profit at the dairy farms is over or around 400,000 DKK. Among the dairy farms, number 3 is the least profitable with a net profit of 4.275 DKK per cow, where the profit is 5,920 DKK per cow at dairy farm 1.

Table 3.6. Net profit in crop and livestock production (1,000 DKK)

Farm	Net Profit Crop production	Net Profit Animal production	Net Profit whole farm
Dairy farm 1	-14	444	430
Dairy farm 2	-5	474	469
Dairy farm 3	-18	398	379
Arable farm 1	-10		-10
Arable farm 2	-33		-33
Arable farm 3	-33	-154	-187
Arable farm 4	-63		-63
Pig farm	78	113	192

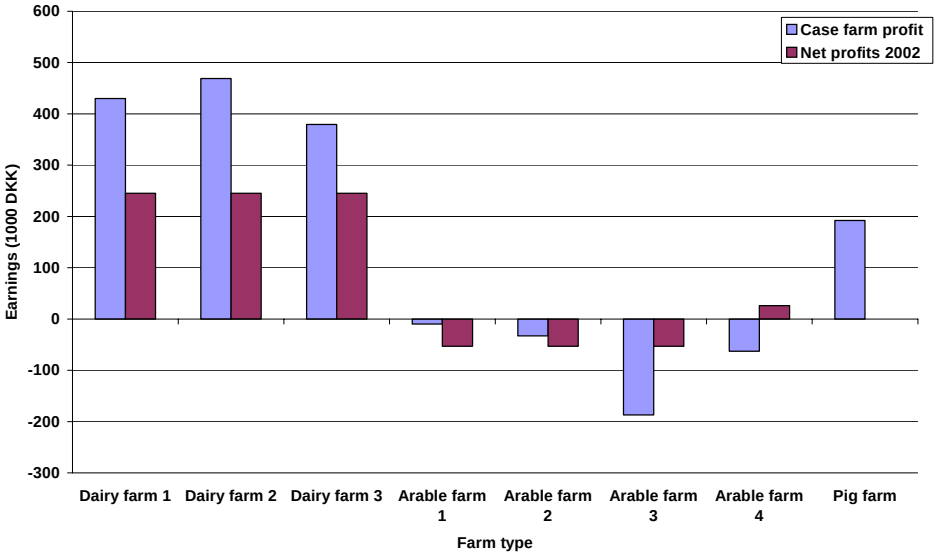
Source: Madsen (2003).

The total farm profit is positive at the livestock producing farms. At arable farm 3 case-farm, a poor economic outcome of raising cattle is the main cause of the large

negative net profit. As a result of the negative contribution from the crop production, every arable farm has a negative net profit, while the outcome at the dairy farms and the pig farm adds up to a positive total net profit.

In figure 3.1, the net profit from the income statistics in 2002 is compared with the net profit on the case farms. The net profit is calculated differently in that the case farm analysis is based on the full cost of machinery and labour, whereas net profit in the income statistics is minus consumption and tax, and the owner is not paid a salary.

Figure 3.1. Profit on case farms compared with net profit in 2002 on comparable farms



Comment: Dairy case farms are compared with farms with over 80 cows. For arable farms, only arable farm 4 is compared with full time arable farms and there is no data for pig farms due to the small number.

Net profit in the statistics is after private consumption and tax, whereas the profit on case farms is after salary paid to all labour and capital.

Source: Madsen (2003) and FOI (2003).

The economic outcome in the crop production at the case farms is, in general, better than expected, based on the accounting statistics (FOI, 2002b). On the dairy farms the higher net profit is mainly caused by higher yield and lower production cost, as a re-

sult of the machinery optimisation carried out by the Danish Institute of Agricultural Science. This procedure makes little room for improvements on these farms. The profit on the arable case farms is at the same level as found in the income statistic.

After the analysis of the base-line scenario, we look closer at the scenarios analysed in this project. The scenarios include new technology, which is discussed in the following chapter and changes in legislation described in Chapter five.

4. New technology

Further development and growth of organic farming requires further cost reductions in order to increase profits, but also in order to lower consumer prices and increase demands. One way of achieving this could be through extended use of new technology. A move in this direction can be seen as a result of the increasing professionalism, specialization and use of more rational production methods on organic farms in the last few years. Based on the relative low returns which organic arable farms have obtained in recent years, it is evident that an increase in the organic production in this sector can only take place if the profitability is improved.

In Action Plan II, it is mentioned that weeding inside the row (between plants) takes 100-300 hrs. per hectare for crops like carrots, leeks and onions (Organic council, 1999). Recommendation no. 10 and 11 from the Organic council was, therefore, to carry out research in order to ensure that organic feedstuffs for the animal production can be increased and the production costs reduced. The recommendation is also to engage in more research into conversion of arable farms on sandy clay and to look closer at specialised crops like sugar beet which are mainly cropped on sandy clay soils. The need for sustainable nutrient flows on these arable farms also is stressed in Action Plan II. Carrots and sugar beet are very labour intensive, although the problem has been reduced through better use and knowledge of the crop rotation, farm management and new technologies.

It should be noted that many of the new technologies would benefit both conventional and organic farming, although the extent will differ. In areas like weed control, technological improvements will have larger impact on organic farms.

The introduction of new technologies in organic farming should comply with certain principles, criteria set by the Danish Research Centre for Organic Farming (DARCOF). The three main principles identified are (DARCOF, 2000):

- The cyclical principle
- The precautionary principle
- The closeness principle (the proximity principle)

The cyclical principle states that collaboration with nature should be promoted. Technologies which might damage natural fertility of the soil should not be promoted. Nutrients are recycled and used again. According to the principle of caution, new tech-

nology is not accepted unless loss of polluting ingredients is reduced and cleaner technology promoted. Known and well-functioning technologies are better than risky technologies where the effects are unknown. It is better to prevent than to depend on our ability to cure the damage. Transparency and co-operation in food production can be improved through the use of proximity or closeness principle. Increased exports of food are, against this principle as the food is not produced where it is sold and consumed. Other writers have the System principle as the third principle, looking at the practices and the impacts on living systems (Alrøe and Kristensen, 2004).

More clear criteria is difficult to state as it also depend on the technology and the situation in question. Some of the new technologies have been evaluated and some are still under debate (DARCOF, 2000). The evaluation of each technology according to main principles are discussed later.

It is to be expected that organic farming will experience the same shift from a labour intensive production towards a more capital-intensive production as conventional farming has experienced.

The technologies chosen here are described in larger detail in Sørensen (2002). The findings in this section build on other ongoing research projects within organic farming under the Danish Research Centre for Organic farming (DARCOF). The technologies discussed in the following include cultivation techniques, weed management, ways of increasing the utilisation of animal manure and new technologies to reduce the cost of milking.

4.1. Cultivation of land

The cultivation of land and the preparation of the optimal seedbed is very important in organic farming as the possibilities of ratifying mistakes later using mineral fertiliser or pesticides is not available. Furthermore, these operations are the most expensive, covering approximately 20-40% of the total machinery and labour cost per hectare depending on the crop.

The following technologies have been suggested:

- Cultivation with spatial variation (GPS)
- Reduce width/depth when ploughing which reduces fuel consumption
- Reduce tyre pressure in order to reduce compaction
- Tools for loosening the soil to avoid compaction

- Transport tracks for application of animal manure and harvest in order to reduce compaction.

None of these technologies is related specifically to organic production and the consequences seems hard to quantify. As a result, these technologies have not been analysed further.

4.2. Weed management

Weed management is an import element in organic production. The basic principle is a strategy where crop rotation and production methods interact in order to reduce the weed problem to a minimum. Mechanical weed control is a necessary production method based on:

- Cultivation
- Weeding
- Hoeing

These techniques mainly reduce the weeds between the rows. In the row itself, other techniques have to be implemented to replace manual weeding. As the following technologies seem promising, they have been selected and are described in more detail:

- Robotic weeding to eradicate weeds in the row
- Band-steaming for intra-row weed control before sowing

4.2.1. Robotic weeding

The aim of robotic weeding is to reduce the manual labour requirement for organic vegetables and sugar beet by 50-100% (Griepentrog & Søgaard, 2003). The prototype technology will be based on a small autonomous vehicle, equipped with RTK-GPS for precision guidance, computer vision for plant recognition and active tools for weed removal. The technology requires that the position of the individual seeds are logged prior to the weeding, in other words during sowing. In this way, the weeding robot may recover the plant positions. The precise position is retrieved by using computer vision for fine-tuning, enabling a close up weeding related to the crop plant. Weeding between the rows is done using traditional hoeing, with or without automatic guidance.

The operational capability of the weeding robot is based on experiences from the development of an autonomous platform (Bak & Jakobsen, 2004; Sørensen et al., 2002) for monitoring of in-field weeds as the basis for weed mapping, displaying intensity and types of weeds distributed throughout the field. Based on an expected lower velocity of the weeding robot when running in monitoring mode and experiences from the development of a weeding machine for maize (Griepentrog & Søgaard, 2003), the operational performance data were derived (Table 4.1). The technology has been accepted using the three main principles of organic farming (DARCOF, 2000).

Table 4.1. Operational and economic parameters of the weeding robot

	Beets/carrots	Units
Operational		
Velocity	1.8	*km/s*
Field efficiency	80	*%*
Working width	100	*Cm*
Capacity	0.18	*ha/h*
Economic		
Investment	200,000	*DKK*
Supervision	2,0	*Hour per 12 hour of operation*
Electricity	100	*DKK per 12 hour of operation*
Maintenance	80	*DKK/ha*

Source: Sørensen (2002) and Sørensen & Nielsen (2003).

The cost of the robot is estimated to 200,000 DKK based on the first prototypes. The robot is expected to have a capacity of 0.18 hectare per hour at a speed of 0.50 meter per second. The weeding robot requires two hours of supervision and 100 DKK in electricity per 12 hours of operation. Maintenance is anticipated to cost 0.040% of the initial value per hour of operation which in this case is equivalent to 80 DKK per hour of operation. Recent research indicates that the assumption with respect to velocity and capacity shown in table 4.1 might be overestimated. The economic consequences of such a deviation in capacity are discussed in the following section.

Table 4.2. Cost estimation for the robot weeding (DKK)

Technical details:				
Weeding intensity (hrs. per ha)		90		40
Utilization (hrs. per year)		180		180
Area (ha)		16,2		16,2
	Per ha	Total cost	Per ha	Total cost
Costs estimation:				
Labour cost before weeding robot	10,260	166,212	4.560	73,872
Labour cost with weeding robot (25%)	2,565	41,553	1,140	18,468
Costs of using robot::				
Supervision	211	3,420	211	3,420
Maintenance and electricity	253	4,092	253	4,092
Depreciation and interest	1,522	24,658	1,522	24,658
Total costs with robot	4,551	73,723	3,126	50,638
Total reduction in costs	**5,709**	**92,489**	**1,434**	**23,234**

Note:
Labour 114 DKK per hour.
The price of the robot weeder is 200,000 DKK.
The area is treated twice a year with the robot.
Lifetime of the robot is 10 years and interest 4% has been used.

Source: Madsen (2003).

The weather conditions in Denmark through May and June makes it likely that the weeding robot can operate for 20 days within this period. Depending on the need of daylight the robot is able to operate 12 or 20 hours a day leaving a window of 240 or 400 possible working hour a year. Only 75% of these hours are accessible for weeding, which leaves 180 or 300 operational hours per year (Sørensen, 2003).

Manual weeding requires 40-90 hours per hectare according to the level of weed (Sørensen, 2003 and DAAS, 2002d). The expected weeding efficiency between 50-100% makes it evident that manual weeding might still be needed after an implementation of robotic weeding. A weeding efficiency of 75% has been used as a point of reference when analysing the profitability of the technology. In case the robot replaces 75% of 90 and 40 hrs weeding, the results in table 4.2 would show a reduction in cost of 5,700 and 1,400 DKK per ha respectively.

Consequences at the case-farms

The following calculations have been based on a high level of weeding and hereby a replacement of 90 hours manual per hectare. The demand of labour is reduced dramatically as expected from the above description of the technology and the stated as-

sumptions. Since the weeding robot is assumed a part of the machinery at arable farm 4, the time spent on maintenance is included in the workload. As it occurs from table 4.3, the relative reduction is 33% in carrots and 65% in beets. This technology does not affect the other case farms as they do not grow row-crops.

Table 4.3. The use of machinery, equipment and labour per hectare as well as relative reduction of labour and equipment when introducing the weeding robot

			----- Resources, hour per hectare -----			-------- Changes --------	
Farm	Crop	Acreage (ha)	Machinery	Equipment	Labour	Equipment	Labour
Arable farm 4	Carrots (Ha)	1	65.3	126	191	10.8%	-33%
Arable farm 4	Beets (Ha)	4	10.1	21.3	51.2	111%	-65%

Source: Madsen (2003).

Since the weeding robot is part of the machinery at the arable farm 4, the use of the resource "Equipment" increases by 11.2 hours per hectare which is equivalent to an increase of 10% for carrots and 111% for sugar beet.

Table 4.4 show that the reduction of labour cost and the increase use of equipment to grow a hectare of either carrots or beets adds up to an overall improvement of the net profit by 4,240 DKK for carrots and 3,860 DKK per hectare for sugar beet. The sugar beet still has a negative profit of –8,290 DKK per hectare, which makes beets an irrelevant alternative. Carrots, on the other hand will become profitable using robotic weeding. If the robotic weeding had been done by a contractor, the cost reductions would have been higher.

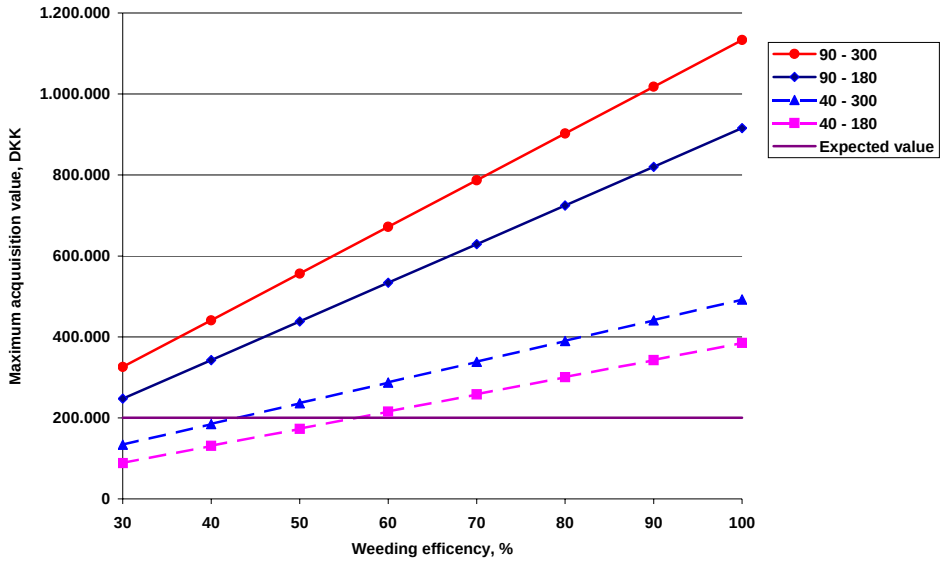
Table 4.4. Total cost, revenue and the actual net profits per ha when using the weeding robot and the changes of the net profits in relation to baseline on farm 4

	Total cost	Revenue	Net profit	
			Absolute	Changes
Carrots	67,800	72,000	4,200	4,240
Beets	20,200	11,900	-8,290	3,860

Source: Madsen (2003).

In an economic setting, the uncertainty of the purchase price is expected to significantly influence the profitability. Focusing on the uncertainty the weeding efficiency, weed intensity, purchase price of the machinery, and area are key parameters. In figure 4.1, the relationship between weeding efficiency and maximum acquisition value (purchase price) is illustrated at different levels of weed intensity and utilization. The first number in the legend indicates the weed intensity indicated by the number of hours manual weeding required before (90 or 40 hrs per ha). The utilization of the machine is stated in the last number in the legend as hours a year (180 or 300 hrs).

Figure 4.1. The relationship between weeding efficiency and maximum acquisition value for a weeding robot at different levels of weed intensity and utilization



Note:
The first legend is the weeding in hrs. per ha the robot replaces.

The second legend is the number of hours per year where the robot is used (16.2 ha is 180 hrs. and 27 ha is 300 hrs.).

Source: Sørensen et al. (2003) and own calculations.

From figure 4.1 it can bee seen that even at a low level of weed intensity (replacing 40 hrs. per ha.) and low utilization (180 hrs. a year), the maximum acquisition value for a rational organic farmer would be 300,000 DKK assuming a weeding efficiency

of 75% for the technology. The analysis is based on a depreciation of 10 years and an interest of 4%. The electricity and labour are fixed, whereas maintenance increases slightly with purchase value.

In case the weeding robot can be used 300 hrs. a year on fields with high weed intensity, a maximum acquisition value of over 800,000 DKK can be paid before the investment becomes unprofitable even with an efficiency of 75% (se figure 4.1) .

As robotic weeding is profitable even with low weeding intensity, low utilisation per year and with low weeding efficiency at the stated price, it is expected that this technology will be used more extensively in the future provided that a well functioning system is developed.

4.2.2. Band-steaming before sowing

A new prototype of an integrated machinery system for weeding involves band-steaming for intra-row weed control. The soil is thermally treated in a narrow band of 8 cm around the crop rows in a depth of 5 cm prior to crop establishment in order to limit the germination of weeds. The subsequent sowing is carried out automatically following a track pre-set by the band-heater. The control of inter-row weeds is carried out by means of traditional hoeing. The system is aimed at increasing organic cropping of row crops, such as outdoor vegetables, maize and sugar/fodder beets. The prototype band-steamer has been developed at the Danish Institute of Agricultural Sciences, Research Centre Bygholm (Melander et al., 2002).

The band-steaming system is anticipated to replace 40 – 90 hours of manual weeding per hectare according to the level of weed intensity. The calculations are based on a high weed intensity, 100% efficiency and thereby a replacement of 90 hours manual work per hectare.

The operational and economic parameters of the band-steaming equipment are outlined in table 4.5. The extensive use of fossil fuel does not comply very well with the organic principles. As a result, it is not given that the technology can be accepted in the organic sector. Another objection is the effect on the microbial processes in the soil.

Table 4.5. Operational parameters and the price of a band-steamer

	4-row system/1493 kW	Units
Operational		
Velocity	2.2	*km/hrs*
Band width	8.0	*cm*
Field efficiency	90	*%*
Capacity	0.40	*ha/hrs*
Economic		
Investment	420,000	*DKK*
Energy, steam generator	320	*L/ha*
Energy, tractor	5.0	*L/ha*
Maintenance	100	*DKK/ha*

Source: Sørensen (2002) and Sørensen & Nielsen (2003).

Based on the parameters in table 4.5 and 135 hours of operating per year, the yearly cost is 904 DKK per hour or 2,260 DKK per hectare (based on 54 ha). The 135 hours of use a year is based on an operational window of 15 days with 12 hours per day and an accessibility of 75 pct. due to the weather. An investment of 420,000 DKK is expected. The cost of using the streamer is estimated to 2,900 DKK per ha.

Consequences at the case-farms

The thermal treating of weed has large impacts on the demand of labour in the production of both carrots and beets. The technology is assumed to replace 90 hours per hectare of manual weeding with a capacity of 2.5 hours per hectare, if management and maintenance is not taken into consideration. In contrast to the analysis of the robotic weeding technology, an efficiency of 100% is assumed. The net profit is improved by 7,350 DKK per ha, based on a partial analysis at full utilisation.

Because of a considerable input of labour in the baseline scenario when growing carrots, the relative effect of changes in weed control is smallest in carrots, as shown in table 4.6.

The reduced input of labour lowers the expenses with respect to wages by the same percentages as already described. The cost item “Contractor” increases by 132% in carrots and beets while the cost of providing shelter decreases by 3%. In total, the costs decrease 15% and 43% in carrots and beets respectively compared to the baseline.

Table 4.6. The use of machinery, equipment and labour per hectare besides the relative reduction of labour input when introducing the band-steamer (farm 4)

Crop	Area (ha)	Resources, hour per ha			Change in Labour
		Machinery	Equipment	Labour	
Carrots	1	65.3	115	155	-45.4%
Beets	4	10.1	10.1	15.5	-89.3%

Source: Madsen (2003).

From table 4.7, it appears that the net profits increase by 10,700 and 10,300 DKK per hectare of carrots and beets respective but it is still only profitable to grow carrots. Due to the high production costs and low revenue, the economic outcome is still relative by poor when growing beets. The thermal treatment replaces a heating operation using a propane burner when growing carrots. That is the reason why the economic effect is largest in this crop.

Table 4.7. Total cost, revenue and the actual net profits pr. ha when using the band-steamer and the changes of the net profits in relation to baseline

	Total cost	Revenue	Net profit	
			Actual	Changes
Carrots	61,300	72,000	10,700	10,700
Beets	13,700	11,900	-1,820	10,300

Source: Madsen (2003).

The uncertainty related to the profitability in thermal treatment of weed is primarily due to changes in price, capacity and the efficiency of preventing weed germinating. The following sensitivity analysis has been limited to variation of price and capacity by +/- 10%. The profitability of the technology is relatively insensitive to deviations in capacity and price. A variation of these parameters of +/-10% affects the net profit by only approximately 100 DKK per hectare.

If the evaluation criteria are economical the band-steaming technology seems promising. A decline in total cost of 10,000 to 11,000 DKK per hectare at 135 hours of operation a year and high level of weed density makes the technology very interesting. The area needed to make the investment profitable will be around only 6 ha based on 90 hrs. full efficiency and a price of 420,000 DKK.

With respect to the principles set up by DARCOF (2000), the technology does not comply with the intention of not harming the nature and also it increases the use of fossil fuel. On the other hand, it does improve the labour environment. DARCOF have placed this technology under both "Under debate" and "Banned", so no clear conclusion has been made yet, but there is some scepticism as to whether the use of a band-steamer complies with the organic principles.

4.3. Optimal utilisation of animal manure using GPS

As the maximal utilisation of animal manure is very important on organic farms, technology which can improve the utilisation of nitrogen is of great interest. The reason for using GPS (Global Position Systems) is to be able to apply the slurry in the right dose according to the conditions at that particular location. The technical analyses indicate that the uncertainty with respect to the allocation of nutrients mainly occurs from the variation in content of nutrients in the slurry than from the allocation in metric tons per hectare.

The GPS system uses knowledge regarding the yields of the previous years when deciding on the level of application. Another interesting aspect would be to relate the allocation level to the cover of N-fixating crops like peas and clover in the previous periods. In this way, slurry would be applied where the fixation is low and the need for nutrient largest.

The investment depends on the equipment which already exists on the farm. For an old slurry spreader, the additional cost of GPS equipment is expected to be 80-100,000 DKK whereas the additional cost on a more up to date spreader with flow measurement is anticipated to be around 20,000 DKK. It is assumed that the lifetime and the maintenance costs are unchanged. The additional costs of the GPS-equipment in order to plot and handle yield maps etc. is not included (Sørensen, 2002).

The results of using GPS related slurry application is still only limited, but the trend seems to be an average yield increase of 3-4% on sandy soil, while a yield decrease on clay soil has been suggested, but not verified.

With a yield increase of 3 pct. or around 150-200 DKK per hectare on 30 hectares, the additional investment of 20,000 DKK is profitable even with a lifetime of only 5 years. However, with a cost of more than 50,000 DKK, the technology is unprofitable, just as a yield increase of only 1% is not enough to pay off the investment.

The conclusion is that this technology is unlikely to be an advantage especially if the possibility of importing manure is low or costly. At the moment the results of the potential effect are not sufficiently scientifically founded for this alternative to be used in the further calculations regarding new technologies.

Other technologies regarding slurry and manure application have also been examined. These technologies include long distance hoses or pipe transportation to reduce compaction and methods to a ensure that farm manure (not slurry) is spread more evenly. The technologies do not provide a major change compared to the systems already used in the base line scenario (Sørensen, 2002 and Sørensen et al., 2003). The technology will, therefore, be accepted in relation to the organic principles, although it is not included in the DARCOF (2000) list.

4.4. New technologies regarding organic livestock production

In general, most of the advantages in conventional livestock production are also used in organic livestock farming. However, requirements regarding livestock density, housing for stables and outdoor area do imply that certain aspects are managed differently on organic livestock farms.

Looking at technological advantages, the most remarkable development has been the change towards automatic milking using milking robots. In the “Automatic-milking” scenario, the technology is introduced on the three dairy case farms. The milk yield is expected to increase 5-15% and milking is more frequent with close to four times a day. The technology is not necessarily in line with the ideal of organic production as grassing during the summer makes the technology less attractive at the moment. Since some of these problems could be eliminated in the near future, the consequences of introducing automatic milking at the case-farms are analysed in section 4.4.1.

Looking for other perspectives one could argue that using outdoor milking parlours would be more in line with the organic concept as both the grazing and the milking would be carried out outside. Throughout the winter the milking parlour could be installed in a stable at the farm. However, it has not been possible to obtain valid information concerning such a system, which is why it is not included in the further analysis.

4.4.1. Automatic milking

To introduce automatic milking at the dairy farms, an investment of 2.4 million DKK is assumed. As shown in table 4.8 the price of two milking units with a capacity of 128 dairy cows are 2.3 million DKK but an investment of additional 0.1 million DKK is necessary to reconstruct the stable where the milking takes place. The variable expenses such as service and maintenance are 40,000 respectively 15,600 DKK a year.

Table 4.8. Investment and variable expenses of two automatic milking units on dairy farms

Investment	
Two milking units	2,300,000 DKK
Other investments	100,000 DKK
Variable expenses and maintenance	55,600 DKK

Source: Sørensen, 2002.

The technology is expected to reduce the input of labour with respect to milking, feeding, inspection and care by 40% and increase the yield by 10% similar to what is obtained on conventional dairy farms.

Consequences at the case-farms

As described above, the workload directly related to the dairy cows is reduced after the implementation of the automatic milking technology has taken place. As a result of the increased yield, the input of "Machinery", and "Equipment" measured per kilo milk is reduced by 9% for dairy farm 1 and 3. The input of labour is reduced by 34%, 45% and 38% at the dairy farms 1 to 3 respectively (see table 4.9).

Table 4.9. The use of machinery, equipment, labour per kilo of milk and the relative deviation compared to baseline

	Cows	Resources, sec. per kg milk			Deviation compared to baseline		
	head	Machinery	Equipment	Labour	Machinery	Equipment	Labour
Dairy farm 1	75	0.87	1.74	10.2	-9%	-9%	-34%
Dairy farm 2	110	0.72	0.93	7.10	-37%	-37%	-45%
Dairy farm 3	93	0.89	1.28	8.65	-9%	-9%	-38%

Source: Madsen (2003).

Because of differences in the utilization of the capacity of the two milking units, the consequences on the maintenance, depreciation and interest cost are lowest at dairy farm 2 with 110 cows and highest at dairy farm 1 with 75 cows. In total, the cost increases by 13% on dairy farm 1, but only 3% at dairy farm 2.

Since the revenue increases by 10% on all of the three dairy farms, the effect of implementing automatic milking on the net profit follows the same tendency as the total costs. At dairy farm 2, the net profit increases from 0.685 to 0.718 DKK per kilo of milk compared to a decrease from 0.667 to 0.514 DKK per kilo at dairy farm 1 (se table 4.10).

Table 4.10. Total cost, revenue and the actual net profits when using the automatic milking and the changes of the net profits compared to baseline (DKK per litre milk)

	Total cost	Revenue	Net profit	
			Actual	Changes
Dairy farm 1	2.37	2.89	0.51	-0.15
Dairy farm 2	2.17	2.89	0.72	0.03
Dairy farm 3	2.27	2.89	0.61	-0.06

Source: Madsen (2003).

The net profit has decreased by 65,300 to 123,000 DKK at dairy farm 1 and 3 compared to an increase of 14,000 DKK at dairy farm 2. To be profitable, the capacity has to be well utilized. Despite a utilization of 86% of the maximum capacity at dairy farm 2, only a net profit of 14,000 DKK is generated.

In the conventional agricultural production the investment, cost structure, workload and yield increase are relative well founded. For the organic production this is not the case. In case the yield fall by 6.5% during the summer compared to the baseline, this leads to a 2.9% reduction over the year if the summer is assumed to last 160 days per annum. If that is the case, then the net profit is reduced dramatically. The reduction in profit ranges from 290,000 DKK at dairy farm 2 to 330,000 DKK at dairy farm 1. The decline emphasizes the sensitivity of the profitability with respect to effect on yield. As a result, the technology is not predicted a great future in the organic sector. Problems concerning yield and grassing during summer have to be overcome and even then a high utilization is a prerequisite.

More recent analyses in Denmark seem to suggest that the increase in yield of 10% is not always obtained (DAAS, 2005). The analyses show that a profit gain is not guarantied, but the robot milking can have other advantages in terms of work load and working hours which makes it an attractive option (DAAS, 2005).

According to the DARCOF principles, robot milking is both listed under "Accepted" and "Under debate", which might indicate that in general there is a positive, but sceptical attitude towards robot milking.

4.5. Conclusions regarding new technology

The effort to find new technologies, which are not currently adopted, is by definition difficult. The difficulty occurs from predicting the future development and the fact that a lot of technologies have been implemented in recent years and, hence, are adopted in the base-line scenario.

Based on a partial analysis, the most promising technologies in the sense of profitability have been selected as objects of further analysis. The calculations regarding new technologies have focused on robotic weeding, band-steaming and automatic milking. In order to be worthwhile, the technologies have to reduce the costs of growing crops or livestock productions and thereby contribute to a substantial difference in income.

From a strictly economic point of view, both the weed management technologies are profitable but band-steaming is superior to robotic weeding. If the capacity of band-steaming and robotic weeding are utilized the cost reduction will be over 5,000 DKK per ha. The uncertainty related to the weeding robot is more distinct than for the band-steaming technology.

The thermal treatment does not fit very well with the organic principles, but tests of different band steaming techniques might reduce the environmental impact in terms of fuel consumption (Melander et al., 2004). As the production of vegetables and beets are rather limited compared to the organic sector as a whole, the weed management technologies are not expected to have great impact on the income at troubled arable organic farms.

In 2003, the total area with organic carrots, onions, cabbage and other vegetables constituted 540 ha and the area with beet (sugar and fodder) has 212 ha. Together this is

0.5% of the total converted organic area in 2003. In terms of turnover the percentage is higher as the product value per hectare is high.

To be profitable, the capacity of the automatic milking technology has to be very well utilized. Even then, the economic benefits are limited. At the case dairy farm 2 where 86 pct. of the capacity is used, only an improvement of 14,000 DKK in net profit is obtained. This is in line with other results suggesting only limited benefits from automatic milking (DAAS, 2005). However, other benefits in terms of working conditions might be obtained. To be worthwhile at all, problems concerning summer grassing have to be overcome. If these problems are overcome, automatic milking could have an impact in the organic sector as dairy farms are the largest group within the organic sector.

The analysed technologies do not seem to have major influence on the future development and income in the organic sector as a whole in the near future.

5. New legislation – 100% organic

As mentioned in the introduction, the difference between organic production and conventional farming has diminished as conventional farmers reduce the use of pesticide and mineral fertiliser. This chapter focuses on the effect of the possible changes in legislation, which might be adopted in the future. The tighter restrictions could help to ensure the current price premium, but can also show the effect of adopting higher standards for organic farming.

The changes in this chapter include the following restrictions:

- 100% organic feed (requirement from 2005)
- 100% organic straw (no import of conventional straw)
- 100% organic manure (no import of conventional manure)

The basic idea behind these scenarios is to calculate the consequences of a 100% organic flow of nutrients and feed. Although not all of the scenarios are likely in the near future, it is intended to pin point the consequences of such a change both in terms of production, income and nutrient surplus at the case farms. It should be noted that Arla in Denmark already requires that the suppliers only use organic feedstuff in order to receive the price premium for organic milk.

5.1. 100% organic feed

Since the consumption of nutrients and feed at organic livestock producing farms have to be completely organic by the end of 2005, the topic is highly relevant. Today, 10 to 20% conventionally produced nutrients and feedstuff is used in organic livestock production. The mark up of organic crops with a high content of protein is considerable compared to similar conventionally produced crops hence the import of such crops at organic farms is relative high. As a consequence the cost is expected to increase quite a lot if the right to import conventionally produced nutrients and feed is lost.

In 2001 ARLA foods introduced an additional price of 10 øre per kg milk if only organic food was used. In 2002, it became a requirement and no additional price was given for milk produced using 100 pct. organic feed.

The calculation in this section does not take into account the uneven distribution of the livestock throughout Denmark. In a national perspective it does not seem unrealis-

tic to implement such requirements but in certain regions it might be a problem to get the necessary organic feedstuff because of the limited production in that region. To simplify the calculations it has been necessary to disregard the transportation cost. In other words, it is assumed that the case-farms are close to one another.

The price assumptions are based on an estimate by sales consultant Lars Balslev, DLG Zealand North (Balslev, 2002). The estimates are shown in table 5.1. Because of the high content of protein in protein feed the largest increase is expected to occur for this kind of feed. The increase is expected to be 0.44 DKK per kilo of protein feed and 0.25 DKK per kilo of pre mixed feedstuffs are anticipated, which is a relative increase of 17 and 10% respectively.

Table 5.1. The price of typical feedstuff containing both organic and conventional feed and 100% organic feedstuff

	Price, DKK per kg		
	Present	Expected	Increase, pct.
Protein feed, sows	2.56	3.00	17
Protein feed, pigs	2.56	3.00	17
Pre mixed feed, young piglets	2.60	2.85	10
Pre mixed feed, piglets	2.60	2.85	10

Source: Balslev, 2002.

Consequences at the case-farms

As the changes in this scenario are limited to the prices of feedstuff, the effect on total cost and the net profit are similar in absolute terms. The net profit with respect to the sows is reduced by 25,000 DKK as it appears in table 5.2. The most conspicuous reduction of 24% and 63,000 DKK is related to the pigs for slaughter. On the pig farm as a whole, the net profit is reduced by 97,900 DKK. Despite the notable reduction in income, the pork production at the case pig farm is still profitable.

Table 5.2. Changes of the net profit in absolute and relative terms compared to baseline on the case pig farm

Farm	Product	Net profit Absolute	Relative
Pig farm	Sows	-25,000	-9%
Pig farm	Piglets (7 – 30 kg)	-10,000	-8%
Pig farm	Pigs for slaughter (30 kg -)	-63,000	-24%

Source: Balslev (2002) and Madsen (2003).

The production stays profitable as long as the price of feedstuff is not twice the expected increase. Because of the huge workload of 2,970 hours a year, even larger price changes can be seen without making the production unprofitable if the farmer is willing to accept a slightly lower wage rate.

Higher prices will indeed diminish the profitability of the pork production in general, but at the case pig farm, the production is still lucrative and not very sensitive to further increases of the feedstuff prices. The conclusion here is in line with other calculations on 100% organic pig production (Tvedegaard, 2005). The consequences for the organic sector are very limited due to the size of the organic pork production compared to the whole sector (see chapter 2).

5.2. 100% organic straw

Straw is an essential input in the organic crop production mainly because of the ability to maintain or contribute to the potassium balance. As the possibilities of importing potassium through feedstuff and manure gets more and more restricted, the value of straw is expected to increase.

The use of straw in the organic sector is demanded as a minimum requirement by law (Danish Plant Directorate, 2000) but the ideals of organic farming and restrictions according to the arrangements of stables, makes it suitable to use more straw. If the use of straw is restricted to organic straw only, a lot of stables are expected to be reconstructed according to consultant Peter Mejnertsen, Danish Agricultural Advisory Centre, Crop production (Mejnertsen, 2002). On behalf of his expertise, the estimated price of organic straw is based on the value of straw as manure and the cost of press-

ing the straw into bales and transportation. The exact figures appear from table 5.3 below. The cost of manure distribution is not included.

Table 5.3. The expected price of organic straw

Organic straw	Value, DKK per tonne
Value as manure	45
Baler	18
Transport to the farm	5
Transport to buyer	5
Total value	73

Source: DAAS (2002c) and Parsby (1996).

Consequences at the case-farms

The crop producers without livestock gain from 6,750 to 15,800 DKK due to a higher price on straw while the cost increases by 650 to 22,600 DKK at arable farm 3 and on dairy farm 3 (see table 5.4). The effect on the net profit at dairy farm 1 and 2 is limited, but positive as they also can export straw. In the case where the price of straw increases more than expected, this trend is going to be more apparent. The economically challenged organic crop farmers gain, while livestock intensive farms are getting less profitable. This will lead to a slightly more equal distribution of income among organic farmers.

Table 5.4. Changes of the total cost and net profit in absolute and relative terms compared to baseline

	Total cost, DKK		Net profit, DKK	
Farm	Absolute	Relative	Absolute	Relative
Dairy farm 1	1,050	-0 %	1,050	0 %
Dairy farm 2	2,540	-0 %	2,540	1 %
Dairy farm 3	-22,600	1 %	-22,600	-6 %
Arable farm 1	15,800	-2 %	15,800	163 %
Arable farm 2	6,750	-2 %	6,750	20 %
Arable farm 3	-650	0 %	-650	-0 %
Arable farm 4	15,800	-2 %	15,800	17 %
Pig farm	-2,701	1 %	-2,700	-1 %

Source: Madsen (2003).

5.3. 100% organic manure

The first step in this analysis is to estimate the import of conventional manure to organic farms. Based on data from Danish Plant Directorate (2002a & 2002b), it is es-

timated that organic farms on average apply 87 kg total N per ha. The data consists of farms which do not apply mineral fertiliser. The application level for this group is around 53-55 kg effective N which corresponds to 85-90 kg total N per ha.

The group defined as organic farms by the Plant Directorate can not be used, as farms in conversion also are included. According to this organic arable farms apply the same amount of mineral fertiliser as farm manure which is unlikely.

Based on an area of 168,000 ha the total use of nitrogen is 14.6 million kg total N. Based on standard figures for animal manure per livestock unit and coefficients from Poulsen et al. (2001), it is estimated that the organic manure production is 11.9 million kg total N. The remaining part is the import of 2.7 million kg total N or approximately 18-20 percent of the total amount of nitrogen used on organic farms.

In case the utilisation of N on dairy farms is lower and the N application on arable farms lower as indicated by some analysis, this will change the results somewhat. The total N application on organic farms would increase and the dairy farms would largely be self-sufficient with N. The import of conventional N would increase to approx 25% - 30% of the total N–application.

In table 5.5, an estimate of the distribution of the animal manure in 2001 is given based on an average utilisation of 65 percent. It is assumed that the imported manure is pig slurry used entirely on organic arable farms, although some might be used on farms which are not livestock intensive. There are probably more transactions between e.g. organic and conventional dairy farms depending on their location and the areas which need manure. Table 5.5 shows that the direct implication of a ban on conventional manure would be a reduction in N-application on arable farms by almost 50 total kg N per ha. However, the chapter will show a more balanced and cheaper adjustment. On a national scale, the band would imply a reduction of 16 kg total N per ha or approximately 10 kg efficient N per ha.

In line with the 100% organic straw and feedstuff scenarios, transaction costs are neglected while estimating the value of organic nitrogen. Transportation is, in this case, the most important of the transaction costs if the uneven distribution of the organic livestock farms is taken into consideration. The effect will be discussed later.

Another important simplification is the steady state approach. The model “FØJO Bedriftsmodellen” is a static model which does not take into account substitution be-

tween inputs and outputs. This simplification is especially critical when key prerequisites like the use of manure change. Adjustments of the crop rotation make it possible to reduce the economic consequences. After having estimated the value of organic manure in this set-up, the topic will be dealt with in more detail.

Table 5.5. Estimated distribution of total organic manure (total N) in Denmark in 2001

	Area (ha)	Andel (%)	Applied manure (total kg N/ha)	Applied manure (tons N)	Total conv. manure (tons N)	Total organic manure prod. (tons N)
Dairy farms	85,850	51.1	86	7,400		10,000
Arable farms	74,600 [1)]	44.4	90	6,700	2,700	1,400
Pig and other farms	7,600 [2)]	5.4	66	500		500
Total	168.000	100	87	14,600	2,700	11,900
(kg total N / ha)				87	16	71

The N application per hectare is based on N application on organic farms in 1999/2000 statistics.
It is assumed that all the imported conventional manure is used on arable farms. Some organic manure is transferred from dairy farms to arable farm today as the manure prod. on dairy farms probably is close to 10 million tonne total N. Organic manure from animals, excluding dairy cows and cattle, constitute 1.4 million kg N, of which some are under arable farms.

1) Horticulture and beef producing farms are included.
2) This category includes poultry farms and what is defined as mixed farms in FOI (2002a).

Source: FOI (2002a), and Plant directorate (2003).

The value of organic manure at the case-farms is based on the crops yield response when applying manure. This response is based on the model "Ø-plan" (Tvedegaard, 1999b). The modelling of the yield in Ø-plan is based on the following independent variables: Crop, underseed, crop in field last year, number of years since the field has been cropped with clover, applied manure during the growing season, the secondary effect of manure applied last year and the type of soil. The model does not include nutrients like phosphor and potassium even though these nutrients are essential to the crops especially if a major reduction in the use of manure is expected. This makes it likely that the value with regard to this certain perspective is underestimated.

The case farms might both have a nutrient application and export/import amount which is different from the national level. Furthermore, also the area on the different types of farms might differ from the national level. In this analysis the area on the case farms is adjusted to fit the national distribution. The difference in use of manure and export will be adjusted which is why the expected amount being ex-

ported/imported might differ from the national level. It is assumed that the price needed to establish equilibrium on the case farm marked is similar to the price needed at the national level.

Before looking at the supply and demand of manure, it is relevant to look at the import and export of manure from the case farms. The analysis shows that the N application of total N is 112 kg N pr. ha on the 650 ha of case farms. This is equivalent to 78 kg effective N of which 24.5 kg effective N per ha is imported. Scaling these results to fit the national distribution of farms, the figures is 98 kg N per ha. This is still higher than the actual figure of 87 kg N per ha showed in table 5.5, but not unlikely. The adjusted import of conventional manure on case farms is also higher (28 kg N/ha) than on the national average in table 5.5. In other words, the higher application on case farms comes mainly from increased import of conventional manure.

Table 5.6. Manure application on case farms

	Case farm area (ha)	Case farm area (%)	N-total application (kg N/ha)
Dairy farms	360	55	141
Arable farms	230	35	70
Pig and other farms	60	9	103
Sum	650	100	
Average (kg N / ha)			112
National average based on case farms			98

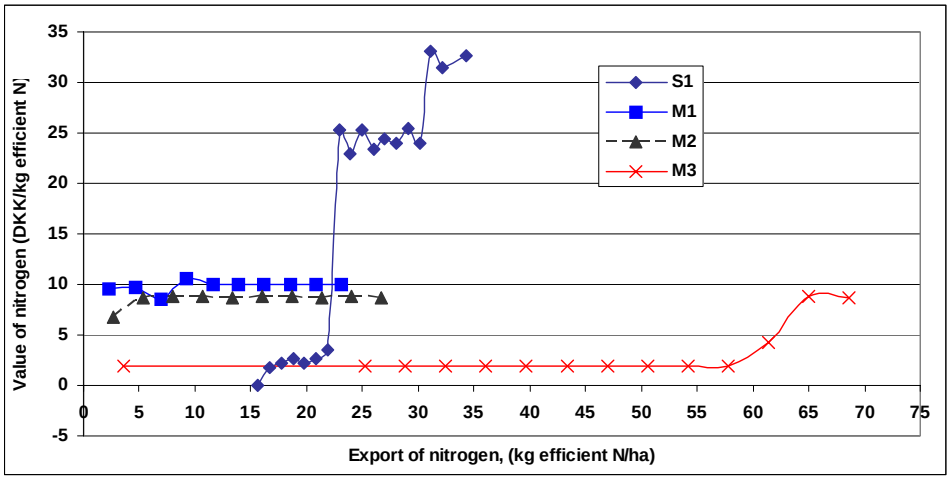
The adjustment factor is calculated as the share of a given farm type on case farms in relation to population in national area. The adjustment factors for the three farm types are: 1.26, 0.92 and 0.49.
The N application is based on analyses made by the Plant Directorate for FOI. (see Tvedegaard, 2002). The utilisation of total N is assumed to be 60%. Using PD figures for total N the level is 117, 125 and 78 kg total N respectively due to a lower utilisation.

Source: Own calculations and Tvedegaard (2002).

In figure 5.1 the supply at the dairy case farms 1 to 3 and from the pig farm is illustrated. The supply has been estimated using an iterative process based on a linear production curve. The applied amount of manure measured in kilo efficient nitrogen is gradually reduced from the level in the baseline to a situation where no or very little nitrogen is applied. By measuring the reduction of the total value and the reduction of nitrogen applied, the marginal value of organic manure is estimated and thereby, the supply curve. The farmer will export as long as the price of manure is higher or equal to the value of applying the manure at the farm.

The need for nitrogen differs a lot between the farms. Pig farm 1 has a surplus of 15 kilos efficient nitrogen per hectare in the baseline scenario. But as the exported quantity reaches 20 kilogram efficient nitrogen per hectare the value increases dramatically because of the crop rotation. On dairy farm 3, the high proportion of nitrogen fixating crops and the high livestock intensity ensures a low shadow value of nitrogen and the export of nitrogen is therefore high. For some reason, the estimated marginal value based on Ø-plan is decreasing at dairy farm 1. In the calculations, this irregularity has been neglected and a constant price of 10 DKK per kilo efficient nitrogen has been used instead, which is the estimated level for exports of up to 12 kg N per ha.

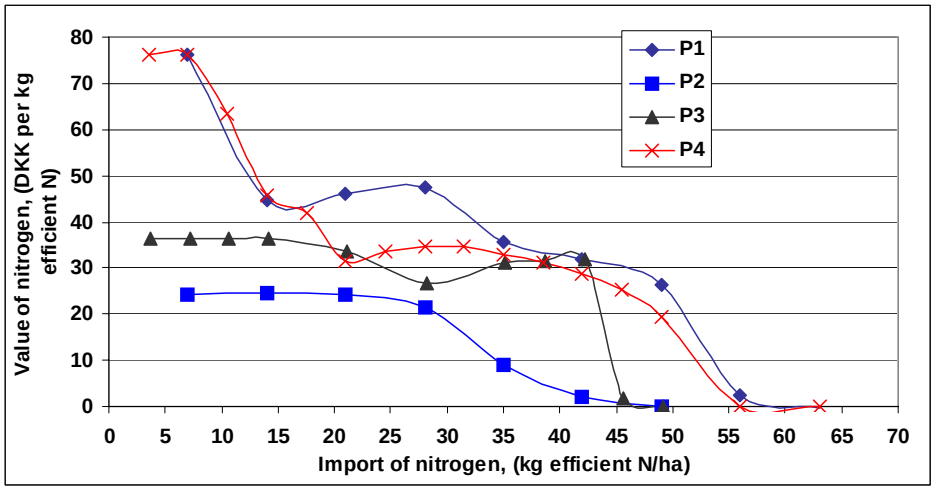
Figure 5.1. The exported kilo per hectare of efficient nitrogen as an inverse function of the price/value



Source: Madsen (2003) and Tvedegaard (1999b).

The demand for nitrogen at different prices/values is illustrated in figure 5.2 for the different farms. In general the value of nitrogen is high at the two arable farms 1 and 4 which grow more specialized crops like potatoes, beets and carrots. The value of the first 5 – 10 kilos of efficient nitrogen is approximately 76 DKK per kilo efficient nitrogen, a very high price compared to the value of nitrogen on other farms importing nitrogen. On arable farm 2 and 3 the value is more constant until a level of about 27 and 44 kilos of efficient nitrogen per hectare. Since arable farm 3 does produce about 11 kilo of efficient nitrogen per hectare the crop rotation on this farm is the most nitrogen demanding at prices below 35 DKK.

Figure 5.2. The imported kilo per hectare of efficient nitrogen as an inverse function of the price/value

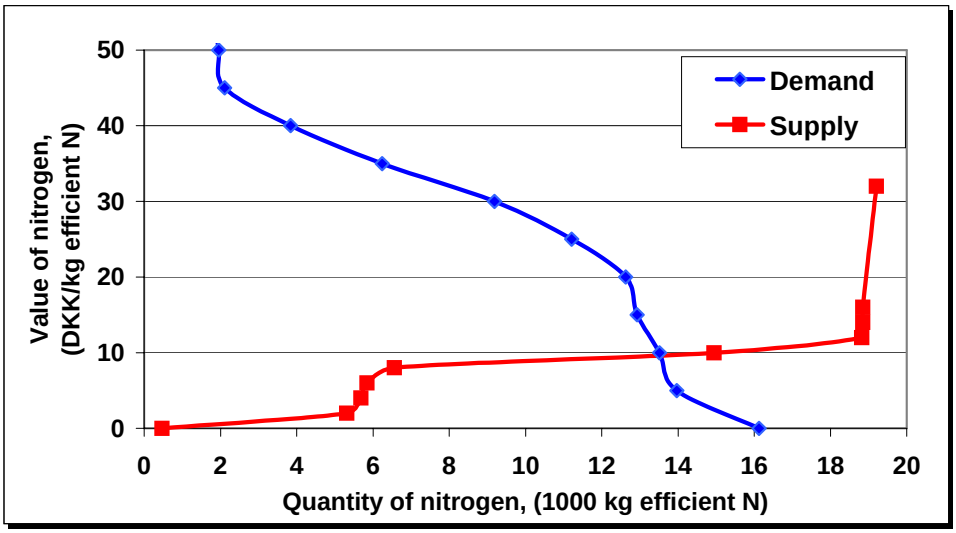


Source: Madsen (2003) and Tvedegaard (1999b).

To estimate the equilibrium price, it is necessary to standardize the acreage of the case-farms to the actual distribution of the different production categories (see table 5.5). The total demand and supply is found by multiplying the actual demand by the standardization rates and afterwards adding horizontally for each price level. In case of the pig farm and the price 10 DKK pr. kg N, it is found that an export of 22 kg N pr. ha is profitable (see figure 5.1). This amount is then multiplied by the correction factor of 0.49 which indicates that the area on pig farms among the case farms is higher than for the total Danish organic area. This adjusted export from this farm type is therefore 22 kg eff. N/ha * 60 ha * 0.49 = 647 kg eff. N. The calculations show that the farm receiving manure, e.g. the arable farm 2, would like to receive 35 kg eff. N at 10 DKK per kg N. The adjusted amount for this farm is 35 kg eff. N/ha * 60 ha * 1.26 = 2.646 kg eff. N.

In other words, the amount for each farm at a given price is multiplied with the adjustment factor. By using this procedure for all farms the equilibrium amount illustrated in figure 5.3 is found. The equilibrium price is 10 DKK per kilo efficient nitrogen which is twice as much as in the baseline.

Figure 5.3. Supply and demand of organic nitrogen (DKK per kg efficient N)



Comment: The equilibrium price is found where the standardized supply equals the demand.

Source: Madsen (2003) and Tvedegaard (1999b).

The somewhat strange appearance of the supply and demand curves is due to the limited number of observations and case-farms. The quantities at the horizontal axis can be seen as the total amount of effective N, which is on the organic marked consisting of the case farms and an area of 650 ha adjusted with the adjustment factor. The relative flat supply curve is due to the flat response from the dairy farms, where a reduction in N-application does not affect the marginal value greatly.

The applied amount of manure measured in both metric ton and kilo of efficient nitrogen per hectare in the baseline scenario and this particular scenario is given in table 5.6 and 5.7. In the base line scenario the pig farm and dairy farm 3 are the only case farms which export animal manure, whereas the rest receives animal manure (see table 3.2).

The reduction in applied nitrogen is striking at the livestock producing farms, especially at the dairy farms 2 and 3. All the livestock farms are now exporting organic manure and all the arable case farms are receiving organic manure, replacing most of

the conventional manure they received before. Dairy farms export 20-70 kilos of efficient nitrogen per hectare and the arable farms purchase 30-50 kg N per ha.

The overall reduction in N application is larger than what is expected on a national scale as the average slurry application is reduced by more than 50 percent from 56 to 31 kg eff. N per hectare.

Table 5.7. The use of manure in the baseline scenario

	Baseline Slurry ton	Baseline Deep bedding ton	Baseline Slurry application kg eff. N/ha	Baseline Slurry import kg eff. N/ha	Baseline Deep bedding application kg eff. N/ha
Dairy farm 1	1,397	41	44	0	1
Dairy farm 2	2,897	62	73	0	1
Dairy farm 3	1,741	51	72	0	2
Arable farm 1	845		53	53	0
Arable farm 2	538		34	34	0
Arable farm 3	555	335	42	42	11
Arable farm 4	824		53	53	0
Pig farm	834	48	55	0	2
Total (tonne)	9,630	537			
Average			56		2

The amount included is the manure applied, delivered by the animals. The import to the dairy farms is not included. Here the application on dairy farms is lower and pig farms higher than end chapter 6.

Source: Madsen (2003) and own calculations

Table 5.8. Manure application and import in baseline compared with the 100% organic manure scenario

	Baseline Slurry application Kg Eff. N/ha	100% organic slurry application Kg Eff. N/ha	Reduction in N-application Kg Eff. N/ha	Import of slurry Kg Eff. N/ha
Dairy farm 1	44	20	24	-24
Dairy farm 2	73	20	53	-53
Dairy farm 3	72	0	72	-72
Arable farm 1	53	47	6	47
Arable farm 2	34	32	2	32
Arable farm 3	42	37	5	37
Arable farm 4	53	42	11	42
Pig farm	55	31	24	24
Total				
Average	56	25	31	

Source: Madsen (2003) and own calculations.

The import of manure at the crop producing case-farms is hardly influenced by the increased price although the source is different as it is now organic manure. The import is only reduced by 2 to 11 kilo efficient nitrogen per hectare, which is markedly less than the decrease in applied nitrogen at the livestock producing farms. On the dairy farms most of the reduction in application is used to increase export as it is more profitable. Note that the low marginal value for Dairy farm 3 results in an export of all slurry.

There is some uncertainty correlated with the results as the case farms and the up scaling is also based on some uncertainty. The sensitivity of the estimated price with respect to acreage distribution of farm type is shown in table 5.9. The equilibrium price and quantity is estimated with changes of the distribution of the different farm types by +/- 4% compared to the actual distribution in the organic sector. As an example the third column shows the situation where the proportion of dairy farmers is increased by 4% while the pig farms (and others) are reduced by the same amount.

Table 5.9. Equilibrium prices and quantities by sequential changes of the acreage distribution between the production categories

Changes of farm distribution by 4 %	+	Dairy cows	Dairy cows	Pigs	Pigs	Crop	Crop
	-	Pigs	Crop	Crop	Dairy cows	Pigs	Dairy cows
Price, DKK per kg eff. N		9.5	9.0	9.0	10.0	10.0	10.0
Quantity, kg eff. N		13,500	12,500	12,500	13,500	14,500	14,500

Source: Madsen (2003).

As table 5.9 indicates, minor changes in the distribution exert only limited influence on the price of efficient nitrogen since the price varies only from 9.0 to 10 DKK per kilo efficient nitrogen. This is due to the relative inelastic supply curve (see figure 5.3). Based on this sensitivity analysis, the conclusion is that the price is expected to increase to 9 – 10 DKK per kg eff. N and the adjusted amount traded between the case farms is 12-14,000 ton eff. N.

Economic consequences for the case-farms

In the crop production, an increase in the prices of nitrogen affects the economic outcome. A lower application of nitrogen on arable farms will lower the yield a little and decrease the revenue. On dairy farms, the reduction in application is significant, but the reduction in yields is not as large as might be expected. The animal farms will on the hand have an income from exporting animal manure to arable farms. In the calcu-

lations this is included as lower costs in the animal production. Also the cost related to the use of contractors will be reduced with lower manure application.

Table 5.10. Total change in net profit compared to baseline with 100 pct. organic animal manure

Farm	Net profit Animal production	Net profit Crop production	Net profit
Dairy farm 1	20,000	20,000	+40,000
Dairy farm 2	40,000		+40,000
Dairy farm 3	30,000	-1,000	+30,000
Arable farm 1		-10,000	-10,000
Arable farm 2		-10,000	-10,000
Arable farm 3	3,000	-10,000	-8,000
Arable farm 4		-7,000	-7,000
Pig farm	10,000	-30,000	-20,000

Source: Madsen (2003).

Behind the increase in net profit in the crop production on dairy farm 1 of 20,000 DKK lies a decrease in income due to lower yields, but also a decrease in costs. The cost reduction is due to lower application costs. There is an increase in profit from animal production due to the higher sales price for manure of 20,000 DKK, which is why the total increase in profits comes to 40,000 DKK.

The arable farms experience a decrease in profit due to purchase of manure, whereas the reduction in yield is limited. Note here that arable farms in baseline scenario pay for conventional manure. The change is therefore only the price difference of 5 DKK per tonne times the change in application, which is why the costs increase is limited.

The overall picture is an increase in profit on dairy farms, but a decrease in profits on arable farms and pig farms. A weighted average indicates a small increase in profit from introducing 100 pct. organic animal manure.

However, there are four important assumptions behind this conclusion:

- Dairy farmers can reduce application of animal manure without reducing their crop output dramatically.
- Organic arable farms pay 5 DKK per kg N for conventional manure in the Baseline Scenario. In practice, some farmers do not pay for either nitrogen or application.

- Organic manure is available in the neighbourhood of organic arable farms.
- The crop rotation on the case farms might be better at keeping nitrogen than the average organic farm.

The implications of these assumptions is that the costs for arable farms are underestimated significantly with the present calculation. The additional transportation costs are analysed in the next section.

National implications of 100 pct. organic manure

The national implications are that the organic sector will use 20 percent less effective N than they do today. The application in the different regions is based on the application on the case farm weighted according to the number of farms in each region. Assumed application is 20 kg eff. N (dairy), 40 kg N for arable and horticulture and 35 kg eff. N for others. Based on the area in each region, the analyses show that approximately 500 tonne total N has to be moved from Jutland and Funen to Zealand. This would require transportation of 145,000 tonne slurry (5.3 kg N/tonne). With transportation costs of around 50-70 DKK per tonne the total cost would be 7-10 million DKK. The cost of 50 DKK is based on transportation distance of 80 km, Jacobsen et al. (2002). Levy for crossing the Great Belt bridge is around 20 DKK per tonne. On top of this comes increased transport of manure within the three regions, which could increase the additional costs to 10-13 million DKK.

Table 5.11. Transportation of organic manure between regions with 100 organic manure requirement (2001 area and production) (total N)

	Area (ha)	Total N produced (tonne N)	Applied (kg total N/ha)	Required organic manure (tonne N)	Required transport (tonne N)
Jutland	144,198	10,510	46	10,200	310
Funen	4,804	450	40	300	150
Zealand	19,368	940	48	1,400	-460
Total	168,370	11,900		11,900	0

Source: Own calculations.

As the arable farms gains and the transport is not a requirement for most organic livestock farms, the arable farms will have to pay the additional costs. The 500 tonne total N fulfils the N requirements on some 10,000 ha (50 kg N/ha) and in case they should pay for the additional transportation cost it would be 700-1,000 DKK per hectare ar-

able area. The conclusion with respect to transportation of manure is that it would not be viable for arable organic farms to receive manure from Funen or Jutland. The Organic farms would have to adjust their crop rotation which would reduce the N-application considerably according to where the receiving farms are located in relation to livestock farms. The yield loss will then be higher than assumed in the previous section but would probably also lead to larger changes in crop rotation mainly on arable farms far from livestock farms. This would also increase the incentive to introduce organic livestock on or near arable farms. The implication might also be a reduction in the organic arable production on Zealand if the growth in organic livestock is limited.

5.4. Lower milk production

According to Arla (Arla, 2003), the production of milk was characterised by an overproduction of approximately 60% from 2002 until today, which means that 60% of the organic milk was sold as conventional milk or conventional manufactured dairy products. Arla Foods have made it clear that this situation is not durable and the market has to reach some kind of equilibrium within the near future. The sensitivity analysis with respect to this scenario has been based upon such a situation, where 40% of the organic milk production has stopped.

A reduction of 40% is equivalent to a reduction of 34,000 Livestock Units (LU). With 1.2 LU per ha the reduction is equivalent to approximately 30,000 ha. The acreage related to other farm types does not change. In such a situation, the distribution of farmland is expected to follow the distribution illustrated in table 5.12. The same relative reduction in milk production is expected in all three regions although this is not likely. The manure production is reduced by 4 millions kg total N.

A 40% reduction of the dairy farms would decrease the organic farmed area by 20% to 135-140,000 ha. Such a change will further decrease the amount of total organic N applied to the remaining fields by 5-10 kg N per hectare as the total amount of N is reduced to 7.9 million kg total N. This would reduce yields and lead to a higher price on N which would force more arable farmers out of the organic sector in case of a 100% organic manure requirement. The amount required to be transported from Jutland to Zealand would increase slightly.

Table 5.12. Transportation of organic manure between regions with 100% organic manure requirement and 40% less dairy cows (2001 area and production) (total N)

	Area (ha)	Total N produced (tonne N)	Applied (kg total N/ha)	Required organic manure (tonne N)	Required transport (tonne N)
Jutland	120,600	7,400	37	6,875	525
Funen	3,200	200	31	150	50
Zealand	14,550	300	39	875	-575
Total	138,350	7,900		7,900	0

Source: Own calculations

Since the profitability on arable farms is relative poor it might be more realistic from a neoclassical point of view to assume that these farms convert into conventional farms receiving environmental related subsidies, but without the organic authorization. Another way of overcoming the increased costs is either increased subsidises or higher prices.

The fact that substitution between different crops in the crop rotation is not taken into consideration, makes it likely that the economic consequences are overestimated. Crops like clover grass, peas and lupines are expected to become more common while crops like maize for silo, spring barley and triticale are expected to become less frequent in the organic sector as the N-price increases. While moving in the direction towards less nitrogen demanding and more fixating crops, the potential consequences of a diminished supply of organic nitrogen are reduced. Moreover, the leaching of nitrogen and other nutrients is anticipated to decline. Another factor is that new research within the topic is going to generate new knowledge on e.g. leaching, fixation and cultivation and thereby reduce the impact of increased prices of nitrogen. The EU reform will also promote more grass.

The reduced allocation of nitrogen might lower the quality of the crop or feedstuff and thereby reduce the revenue. Also the cost of transporting manure will be higher than calculated here if the manure is transported across the country.

5.5. Conclusions regarding new legislation

Legislation ensuring that all feed used in the organic sector is organic would increase the price of feedstuff by 10 to 17% and decrease the profitability on the case pig farm by 97,900 DKK. The pork production on the case farm is profitable. Due to the relative size of the organic pork production, the consequences of more restricted feedstuff requirement for the organic sector is limited as the dairy sector has already adjusted to this requirement.

If the use of conventional straw on organic farms is no longer permitted the price of straw will increase. The price increase improves the profitability of the net exporters of straw. The arable case-farms without livestock production especially will benefit from the regulation. The net profit at arable farm 1 and 4 is increased by 15,800 DKK while the profit is reduced by up to 22,600 DKK at the livestock case-farms. In reality the effect at the dairy farms are probably underestimated since the stables at the case-farms are organized with straw saving fixtures.

A ban on conventional manure on organic farms will increase the price of N, lower the N-application and lead to more transportation and a redistribution of the organic manure. With an import of conventional manure of 18-20%, a ban will have some practical interpretations. A qualified estimate of the manure price is 10 DKK per kilo of efficient nitrogen based on the yield response estimated in Ø-plan (Tvedegaard, 1999b). A doubling of the N price from 5 to 10 DKK improves the economic outcome at the dairy farms by 30,000 to 40,000 DKK while the profit is reduced by 7,000 to 20,000 at the rest of the case-farms. As the profitability of the arable farms is poor in the baseline scenario such a movement is threatening the existence of these farms. The N application is 40 kg eff. N per ha on arable farms and 20 kg eff. N pr. ha on dairy farms. The economic impact in the sector might be limited as manure from dairy farms is moved to other farm types which can generate a higher income. In the calculations long distance transportation costs are not included. The transportation between regions is estimated to 7 million DKK and with the increased transportation inside regions, the total cost could well be 10-13 million DKK. If the arable farmers have to pay this price, many arable farms will not be profitable, which is why they will stop organic production, although their N application is changed less than for other farm types. Alternatively, they will have to start a livestock production.

A reduction in the organic milk production by 40% as a consequence of the overproduction is expected to reduce the organic area by 30,000 ha. This would increase the

price of N and further reduce the organic N application per hectare by 5-10 kg total N per. ha in equilibrium.

The costs in these calculations might be overestimated since adjustments of the crop rotation is not taken into consideration. A more intensive adaptation of catch crops and underseed reduces the leaching and increases the fixation of nitrogen and thereby reduces potential consequences of a diminished availability of nitrogen. Moreover, less nitrogen demanding crops like e.g. clover grass, peas and lupins are expected to become more frequent, while crops like maize, spring barely and triticale will becoming less regular.

Many organic farms today receive their manure free of charge. Here it is expected that they pay 5 DKK pr. kg N. The increase in costs for these farms due to 100 % organic manure would be higher than calculated here.

The costs for the dairy farms of reducing their N-application might be underestimated, but the calculation also suggests that some organic dairy farms could join arable farms and together increase the income compared to the level today.

The overall conclusion is that 100 organic legislation will be costly, especially for the arable farms which today have a low income. It will increase the tendency towards mixed farms and regional concentration of organic farms. The price obtained will, furthermore, be important as there is no guarantee that consumers will pay an additional price for 100% organic products.

6. Nitrogen, Phosphor and Potassium balance for the case farms

One of the concerns regarding especially the organic crop rotation is the nutrient balance. Where the concern on most conventional farms is the limitations regarding application of total nitrogen and phosphorus, the concern on organic farms is to ensure a nutrient balance and avoid depletion in the long run. In this chapter, the nitrogen (N), phosphorus (P) and potassium (K) balance for each case farm is constructed. The effect of 100 % organic legislation on the N, P and K balance is then examined.

6.1. Application of nitrogen, phosphorus and potassium on the case farms

The calculation of the nitrogen input and export is based on a calculation of the nutrient surplus at the field level. The surplus therefore, does not include e.g. the nitrogen loss in buildings due to ammonia emissions etc. as the input to this balance is the nutrients from the storage. Included in the nitrogen input is nitrogen from animal manure, deposition from the atmosphere, nitrogen fixations and seed. The nitrogen from animal manure is the total N (ab storage). The nitrogen output consists of nitrogen in crops and straw (see table 6.1). The total surplus is then the nitrogen which is either lost as ammonium, leached, transformed (denitrification) or stored in the nitrogen pool. No attempts have been made to decide how much of the total N-loss belongs to each category.

The N-fixation can vary from crop to crop and according to the yield and other N-input to the crop. An average of 150 kg N per hectare for clover has been used. The deposition is set at 15 kg N per ha for all case farms. The content of nutrients in manure is based on Poulsen et al. (2001) for the systems analysed in Jacobsen et al. (2002).

Tabel 6.1. Nitrogen and phosphorus inputs in seed, manure and fixation

	Amount (tonne/ha)	Kg N/tonne dry matter	kg N/ha	Kg P/tonne dry matter	kg P/ha	Kg K/tonne dry matter
Seed:						
Cereals	0,16	17,3	2,4	3.5	0.5	4,8
Peas	0,20	39,7	6,7	4.9	0.8	1,14
Animal manure:[1)]						
Pig slurry (ab storage)		5.2		1.5		2,4
Dairy slurry (ab storage)		5.4		1.0		5,4
Dairy deep bedding		11,2		0,6		10,0
N-fixation:[2)]						
Peas	3.0		110			
Peas/cereals, whole crops			50			
Clover			150			
Lupins			100			
Lucerne	7.2		320			
Deposition:			15			

Comments: An expected utilisation of 75% on nitrogen in pig slurry and 70 % on nitrogen in N dairy slurry is expected and required according to the legislation. The required utilisation of N In deep bedding is 45%.

Source: [1)] Jacobsen et al. (2002), [2)]Kyllingsbæk (1999) and Kristensen and Kristensen (2002).

The nutrient content in the crop production is showed in table 6.2. The calculation is then based on the amount of nutrient per tonne dry matter. As shown there are large differences in dry matter percent between the different crops. Note that the nutrients produced per ha are larger for forage crops than for cash crops.

It is assumed that pig slurry is utilised by 75 percent and that slurry from dairy cows is utilised by 70 percent. For deep bedding the utilisation with respect to N is 45 percent. On average, the nitrogen in manure is utilised 65-70 percent. This can be used to calculate a net surplus where the nitrogen input is the effective N applied to the field according to the legislative requirements.

For each farm the N, P and K surplus has been calculated based on the figures in table 6.1 and 6.2. There is a large variation in the N-surplus over the crop rotation as the application of N and the fixation varies and in some years far exceeds the need. However, this surplus is utilised the following year where the nitrogen required is lower than what is applied. This reduces the risk of leaching. No attempts have been made to calculate the leaching for the case farms. It is clear from the calculations that the N-fixation is important for the total N input to the crops (calculated as the total N applied minus N from animal manure and deposition of 15 kg N per ha in table 6.3).

Table 6.2. Nitrogen and phosphorus for some output from crop production

	Yield (tonne/ ha)	Dry matter content (%)	Kg N/ tonne dry matter	kg N/ha	Kg P/ tonne dry matter	kg P /ha	Kg K/ tonne dry matter	kg K /ha
Cash crops:								
Barley	4.0	85	17.3	58.8	3.5	11.9	4,7	16.0
Wheat	5.0	85	18.4	78.2	3.1	13.2	4,8	20.4
Rye	4.5	83	15.6	58.3	3.0	11.2	5,5	20.5
Peas	3.0	85	33.7	101.2	4.9	12.5	11,4	29.1
Oats	4.7	83	16.6	64.8	3.8	14.8	5,0	19,5
Triticale	4.0	85	16.9	57.5	3.5	11.9	6,4	21.8
Potatoes	18.0	24	14.7	63.5	2.1	9.1	20,0	86.4
Sugar beet	45.0	22	9.4	93.1	1.7	16.8	21,0	208.9
Carrots	50.0	10	16.8	84.0	3.0	15.0	28,0	140.0
Straw:								
Barley	2.4	85	6.4	11.1	0.9	1.8	20,0	40.8
Wheat	2.4	85	5.3	9.2	0.9	1.8	15,0	30.6
Oats	3.0	85	5.9	12.8	1.4	3.6	21,0	53.6
Rye	2.7	85	6.1	11.9	1.0	2.3	10.0	23.0
Ærtehalm	1.65	87	11.5	14.4	2.0	2.9	7,5	10.8
Forage crops:	FE / ha	ts/ha						
Clover	6.400	7.2	38.0	272.4	4.0	28.7	29,0	207.9
Lucerne	7.000	8.4	30.4	255.4	2.8	23.5	28,0	235.2
Peas/Barley whole crop	6.500	7.5	26.7	199.6	3.3	24.7	21,0	157.0
Maize	5.000	5.9	16.0	93.6	3.0	17.6	16,0	93.6
Catch crops	1.200	1.3	33.6	43.1	4.3	5.5	35,0	44.9
Lupins	1.500	1.8	67.0	120.6	4.7	8.5	14,0	25.2

Comments: The yields are illustrative examples, but the yields on the case farms for a given crop depends on the crop in the year before amongst other things. The yields has been determined using the Øko Plan model (Tvedgaard, 2000a+b).

Sources: Kyllingsbæk (2000), Tvedgaard (2000a+b) and table over content in feed items from the Danish Agricultural Advisory Service.

The P-balance calculation shows a deficit for some of the farms, but the overall picture is balance between applied and removed. With respect to K, there is, for most farms a deficit of more than 20 kg K per ha. This is higher than expected. There is therefore a need for application of K in other form than through animal manure to avoid depletion and lower yields (see also figure 6.1). The surplus on arable farm 3 is due to large application of deep bedding.

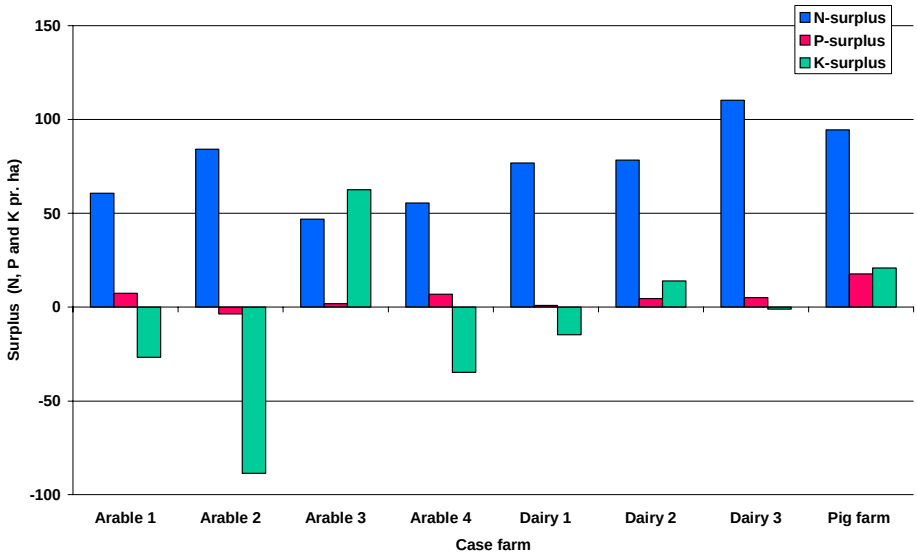
Table 6.3. Total nitrogen, phosphorus and potassium field surplus on case farms

Case farm	Input livestock (kg N/ha)	Input totalt (kg N/ha)	Output (kg N/ha)	Surplus (kg N/ha)	Input P (kg P/ha)	Output P (kg P/ ha)	Surplus P (kg P/ha)	Surplus K (kg K/ha)
Arable farm 1	70	128	67	61	20	13	7	-27
Arable farm 2	46	218	134	84	13	16	-4	-89
Arable farm 3	97	134	88	47	17	16	2	62
Arable farm 4	70	124	69	55	20	13	7	-35
Dairy farm 1	132	232	155	77	23	22	1	-15
Dairy farm 2	139	230	152	78	25	20	5	14
Dairy farm 3	155	289	179	110	27	22	5	-1
Pig farm	103	161	67	94	29	12	18	21

Input consists of nutrient animal manure, deposition and fixation. Output consists of nutrient in crops and straw.

Source: Own calculations.

Figure 6.1. Field surplus of N, P and K on 8 organic case farms



Source: Own calculations.

6.2. N and P-surplus on case farms compared with surplus on organic farms in general

Compared with representative organic dairy farms the field surplus described above is slightly lower than reported for the year 2002 (Kristensen, 2005). The total N-surplus for the organic dairy farms is calculated to 122 kg N pr. ha of which 105 kg N pr. ha comes from the field surplus. This is slightly higher than the 47-110 kg N per ha reported for the case farms in this project.

Of the 105 kg N pr. ha lost in the field, estimates indicate that 43% is leaching, 33 % changes in soil pools and 12% denitrification (Kristensen, 2005). The remaining 12% is ammonia emissions lost during application of manure. There is some uncertainty related to such estimates, but it does give an overall indication of the distribution of the N loss on organic dairy farms. The large difference in K-surplus between arable farm 2 and 3 (P2 and P3) is because on P2 pig slurry is applied with a low content of K and no deep bedding. Furthermore, the crops in P3 include lucerne which removes much K from the area.

The general conclusion on conventional farms is that the N-surplus is largest on dairy farms and lowest on arable farms. It is expected that this is also the case on organic farms. It is, furthermore, concluded that N-surplus and N-leaching from organic farms generally are lower than for conventional farms (Kristensen, 2005).

6.3. Change in nutrient surplus due to 100% organic regulation

The changes in technology described earlier will not change the N-surplus calculation largely as the yield and N-application is unchanged. In this section, the analysis is focused on the effect of a 100% organic manure legislation on the nutrient balance.

The main changes compared to the base line scenario is mainly a lower manure application primarily on dairy farms. The effects on yield has been described using the Ø-plan calculations (Tvedegaard, 2000a). Furthermore, it is assumed that the N-fixation in clover increases from 150 to 180 kg N per ha as the application of slurry decreases.

The new nutrient balances are described in table 6.4. The general picture is lower N-surpluses and larger P and K deficits than in the baseline scenario. This is expected as the application is reduced and the yields are only reduced a little. It is, of course, a

question whether the new yields can be maintained over a longer period of time with deficit especially of K.

Table 6.4. Total nitrogen and phosphorus field surplus on case farms in case of 100% organic feed

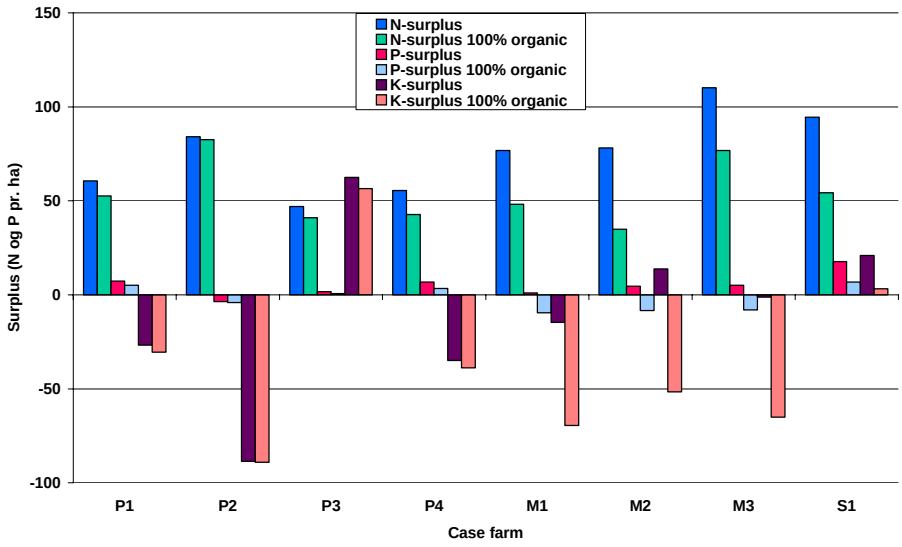
Case farm	Input livestock (kg N/ha)	Input total (kg N/ha)	Output (kg N/ha)	Surplus (kg N/ha)	Input P (kg P/ha)	Output P (kg P/ha)	Surplus P (kg P/ha)	Surplus K (kg K/ha)
Arable farm 1	62	120	67	53	18	13	5	-31
Arable farm 2	44	216	134	83	12	16	-4	-89
Arable farm 3	91	128	87	41	16	16	1	57
Arable farm 4	58	112	69	43	16	13	3	-39
Dairy farm 1	63	188	140	48	11	20	-10	-69
Dairy farm 2	42	158	123	35	7	15	-8	-52
Dairy farm 3	47	215	138	77	8	16	-8	-65
Pig farm	62	121	66	54	18	12	7	3

Input consists of animal manure, deposition and fixation. Output is crops and straw.

Source: Own calculations.

It seems possible to almost maintain a P-balance on the organic farms, whereas there is clearly a K-deficit both in the baseline and even more so in the 100% organic scenario.

Figure 6.2. N, P and K surplus on case farms in baseline and with 100% organic scenario



Source: Own calculation

7. Conclusions and perspectives for organic farming at the farm level

Organic farming in Denmark has, after a number of years with growth, now experienced recession in both area and number of converted farms. The organic area in 2005 is, hence, only half of what was expected in the Action plan II from 1999 of 300,000 ha.

The organic sector today consists of two main types of farms. Large dairy farms and small part time arable farms. The dairy farms are larger than conventional dairy farms with over 100 ha per farm and little income from outside agriculture. They occupy 26% of the farms and 46% of the area.

The other type is small part-time arable farms with a large income outside agriculture and low agricultural income. They constitute 55% of all farms and 38% of the area. The large income outside farming makes them more likely to stay in the organic sector, although their production is not profitable.

The organic dairy farms are expected to face reduced prices in the years to come, both as a result of the EU reform and in order to lower the surplus of organic milk in Denmark. An expected target would be a milk production of 20-25% over the consumption in order to ensure that there is organic milk every day of the week all year round. In order to achieve this, the organic dairy farms might perhaps face a reduction in the additional price premium or other restrictions. This could reduce the organic area by 30,000 ha (20%). The organic area could than be reduced to 130,000 ha.

The recent trends indicate that increasing the export is not as easy as expected. The success for export of conventional products can not be copied as countries in line with organic principles, prefer domestic products (e.g. Swedish milk). The way forward seem to be to reduce costs and/or increase demand. The promising technologies analysed in this report are robot weeding, band steaming, manure application with GPS and milking using robots. There is a potential for reducing costs when producing more specialised crops like sugar beet and carrots, whereas no new technologies seem available in order to reduce production costs on cereals or forage crops. The technologies will reduce labour costs significantly, but increase capital costs. In regions where it might be difficult to hire labour to do the manual weeding, technology might be a solution.

In relation to the organic principles the technologies analysed are mostly accepted or still under review. Some aspects of the technologies have to be examined more closely before they can be finally accepted. It seems that band-steaming is the least accepted of the technologies analysed, whereas robot–weeding is an accepted technology. They both seem to be able to increase profits if they are well utilised. Robot milking is almost accepted, but the high cell counts could be a problem.

For arable farms to be competitive in the future, they will have to be larger, include specialised crops and probably take advantage of new technology whenever possible. The income statistics today already show that in 2002 and 2003 these large arable farms did make a profit, which was in line or better than conventional fulltime arable farms.

To justify the additional price for organic products the organic sector needs to ensure that their products are different from conventional farm products. As the conventional farms e.g. reduce the use of pesticides, organic farming will have to make changes to ensure that there is a difference. The change analysed in this report is based on a 100% organic scenario, where the farms may only use 100 pct. organic feedstuffs, use 100 pct. organic straw and use 100 pct. organic manure.

The analysis shows that using 100 pct. organic straw will benefit the arable farms, whereas the use of 100 pct. organic manure will benefit the dairy farms. The use of 100 pct. organic feed is already introduced for dairy farms and an introduction on pig farms will further increase the costs on these farms. The conclusion is that 100 percent organic farming probably could be a future requirement which will improve the profit on dairy farms and increase the costs on arable farms. The price on nitrogen will increase from 5 DKK pr. kg N to around 10 DKK per kg N in the 100% organic manure scenario.

The implication of changes in legislation would be that the transportation cost would increase as most dairy farms are situated in the southern part of Jutland and many arable farms are situated on Zealand and Funen. The legislation might therefore lead to improved co-operation at the regional level between dairy farms and arable farms as one produces the manure and the other could produce the protein. A reduction in the number of dairy farms would further increase the price of nitrogen and the costs for the arable farms.

Changes in crop rotation are not included and this would lower the effect on nitrogen prices. The analyses also show that the regional imbalance would imply that organic arable farms on Zealand would either farm without organic manure or start a small animal production themselves as the transport of manure from Jutland is too expensive. The conclusion is that this regulation would further increase the difference in income between dairy and arable farms. A 100% organic scenario would be especially costly for arable farms on Zealand.

The subsidy level has not been altered in these calculations but the trend seems to be that the consumers will have to pay the additional prices if they want organic products. It is not unlikely that organic milk prices will come closer to the conventional price. The general principle stated by the ARLA board in the Autumn 2003 is that the organic sector should be running according to commercial principles. The additional price for the year 2004/05 is still 40 øre above the price of conventional milk.

A reduction in the organic milk price has been discussed, but so far only newly bought milk quota for organic farms will not gain a price premium. A minor price war on organic milk in April 2004 could indicate that the price might have to be reduced further (ARLA, 2004). Initiatives to increase organic milk consumption have helped to increase the consumption a little. In 2005 still only 40% of organic milk is sold as organic.

Another initiative by ARLA foods is to reduce the environmental impact of milk production. As part of this strategy, all dairy farms should comply with certain environmental standards and goals by the end of 2005/06. The aim is that all milk producing farms in Denmark and Sweden at the end of 2005/06 will be certified according to ISO 14001 standards. On 1st October, 2002 a total of 40% of all farms were certificated (ARLA, 2004). More requirements might increase costs and reduce the number of dairy farmers.

Although some dairy farmers might change back to conventional farming, they will probably still use very little pesticides and use the crop rotation more actively in order to reduce N-leaching as they have become used to doing as organic farmers.

The nutrient balance on the case farms shows that there is a nitrogen surplus of 75-100 kg N per ha, which is lower than for conventional farms. The analyses also show a balance between P applied and P removed with crops, whereas there is a deficit with respect to potassium on some farms. The 100% organic manure scenario reduces the

N-surplus and shows how it might be difficult to maintain P-balance on organic farms. Additional potassium from other sources needs to be applied to ensure a near balance situation for K.

In conclusion the organic sector is in a difficult position with overproduction of organic milk and low income on small arable farms. New technologies does suggest new ways to reduce the costs, but only for farms with specialized crops. Stricter legislation is likely and this will increase costs especially on arable farms, but benefit livestock farms. The sector will also be faced with a challenge to ensure the P- and K-balance in order to maintain the yield levels in the long run.

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Appendix 1. Number of organic farms and area with authorizations

Table A.1. Number of farms and area given authorization to farm organically

Year	Fully Converted	2. year Conversion	1. year Conversion	Not converted area on organic farms	Total organic area	Number of organic farm (end of year)	Area per farm
	Ha	Ha	Ha	Ha	Ha	No.	Ha
1988					5,880	219	26
1989					9,554	401	24
1990					11,581	523	22
1991					17,963	672	27
1992					18,653	675	28
1993					20,090	640	31
1994					21,245	677	31
1995	17,032	3,668	17,634	2,550	40,884	1,050	39
1996	20,193	17,826	6,970	1,180	46,169	1,166	40
1997	37,033	7,109	15,822	4,366	64,330	1,617	40
1998	44,102	18,203	30,894	5,962	99,161	2,228	45
1999	60,232	36,924	39,473	10,056	146,685	3,099	47
2000	93,354	43,561	20,745	7,597	165,258	2,466	48
2001	131,986	24,635	11,756	5,120	173,497	3,525	49
2002	148,301	16,241	9,808	4,009	178,359	3,714	48
2003	149,157	12,277	3,714	2,876	168,022	3,510	48
2004[1)]	149,401	5,707	1,773	3,327	160,209	3,166	51
2005[2)]					154.000	2,900	53

1) Preliminary figures farm the Danish Plant Directorate.
2) Prognoses based on figures from Danish Agricultural Advisory Centre (DAAS, 2004).

Note:
Total organic area includes fully converted, area under conversion and not converted area on organic farms.

Source: The Danish Plant Directorate (2004).

Appendix 2. Number of organic farms using different statistics

The number of organic farms stated in different statistics is not always the same as they come from different sources and are made for different purposes. This appendix treys in short to describe the differences and the reasons for these.

The main data sources in this area are: The Danish Plant Directorate (authorisation), The Directorate for Food, Fisheries and Agro Business (subsidy) and The Research Institute of Food Economics (income).

The Plant Directorate gives authorization to farms for them to sell their products organically the following year. The authorisation is given on an annual basis. Farms who do not perform according to regulations will have their authorisation withdrawn. The farms are divided into farms which are fully converted, under conversion (1 and 2 year) or conventional crop area on organic farms. Also, the total production in terms of crops and animal production is listed. The authorizations are given in September.

Danish Statistics also publish the organic area based on figures from the Plant Directorate. In order to compare with conventional farms they exclude forestry, which constituted 2,532 ha in 2003. Furthermore the number of farms is based on the situation in April 2004 and not January as used by the Plant Directorate (DS, 2004).

Farmers who receive a subsidy from the Directorate for Food, Fisheries and Agro Business commit themselves to organic farming for the following five years. They need the authorisation to get the subsidy, but they can decline the subsidy. The application is made in the Autumn and the subsidy year follows the calendar year. The subsidy area is the area for which farmers receive subsidy in December of that year. Farmers who are in doubt over the number of years they want to farm organically can therefore choose not to apply for organic subsidy. The subsidy includes both a higher subsidy in the transition period specific for each type of enterprise and organic subsidy when the farm is fully converted. Part of this subsidy is financed by the EU, which demands that the agreements have a period of 5 years.

From 2004, the subsidy year starts on the first of September and runs for 5 years with application in the Spring. Also part of the subsidy has changed name as the subsidy is given to farms with a lower environmental impact (no pesticides etc.). The authoriza-

tion as an organic farmer is no longer needed to get this subsidy. The conversion subsidy still requires an authorisation.

The number of farms which received subsidy for organic production from the Directorate for Food, Fisheries and Agro Business, were a little lower than the number of farms with authorisation. For 2002, the number of farms receiving subsidy for organic farming is 3,550 compared with 3,710, which have an authorisation. So around 96 percent of all farms with an authorisation receive subsidy and the area on these farms is 167,000 ha. This is 93 percent of the area with authorisation minus the area farmed conventionally on organic farms.

The reason for these differences are many but include that some of the area given an authorization are crops which dos not give a subsidy. Also farmers buying more land do not take the entire area in when applying for subsidy as a large increase means that they start on a new 5 year period. Finally, areas receiving subsidy under Environment by friendly schemes cannot receive organic subsidy as well.

On top of this comes farmers who know that they will not be farming organically for another 5 years and they will not start a new period. The conclusion is, therefore, that the difference between authorisation and area given subsidy is only very seldom due to farmers not wanting to receive the money. In general the Directorate for Food, Fisheries and Agro Business register new organic farmers later than The Plant Directorate. On the other hand, farmers who want to stop organic farming disappear earlier in the Plant Directorate than in the subsidy overview. Finally, some might farm organically without requesting an authorisation or receiving a subsidy. The number of such farms is probably limited and not included in either statistics.

Table A.2. Number of organic farms with authroization compared with area receiving subsidy and included in the income statistics

	Plant directorate (Authorizations)		DFFE (subsidy)			FOI (accounts)		
	No. of farms	Area (ha)	No. of farms	Area (ha)	Share of auth. %)	No. of farms	Area (ha)	Share of auth. %)
2001	3,525	173,497		166,400	96	2,492	144,536	83
2002	3,714	178,360		171,800	96	2,496	139,776	78
2003	3,510	168,024		166,300	99	2,262	137,982	82
2004 (prognose)		160.000	2.965	156,618	98			

Source: Plant Directorate (2004), DFFE (2004) and FOI (2004).

The Plant Directorate also publishes fertiliser accounts based on their control reports. In that publication they also have a group named organic farmers. For the fertiliser year 1999/2000 a total of 2.611 organic farms are included in the statistics. The total area constitutes 146,853 ha. Note here that farm holdings where only a specific part of the farm is farmed organically are also included as well as farms which have only applied but not received their authorisation for organic production. The statistics concerning the fertiliser use on organic farms is, therefore, not appropriate to use when discussing the nitrogen application on organic farms. The amount of mineral fertiliser applied is 6-10 kg N per. hectare 1999-2001 and not zero as one would expect. Furthermore, the statistics do not yet include figures on the use of conventional manure on organic farms, which would be useful.

Data on manure application on organic farms could be collected from farms not applying mineral fertiliser. Statistics of such a sub-sample have been requested by FOI (Tvedegaard, 2002a). The results cover 4,697 farms with an area of 205,000 ha, which means that not all have an authorization as organic farms.

Table A.3. Number of farms and manure application on farms not using mineral fertiliser

	Number	Area per farm (ha)	Share of total area (%)	Applied nitrogen (ab storage) (kg N/ha)	Applied effective nitrogen (kg N/ha)
Dairy farm	1,895	56,4	52	117	49
Pig farm	286	34,1	5	79	38
Arable	1,598	42,1	33	117	55
Mixed	918	33,1	15	77	40
Total	4,697	43,5	100	115	47

Source: Tvedgaard, 2002a.

Finally, the Research Institute of Food Economics yearly produce statistics standing the income in organic farming. The number of farms included in these analyses is somewhat smaller than the figures used by the Plant Directorate for the following reasons:

1. Farm holdings which are defined as having both a farm with conventional farming and a farm with organic farming are not included.

2. The area grown organically may not differ more than 75% between the area used by The Plant Directorate and the area used by Denmark Statistics.
3. Farms with less than 10 ha are only included if their European Size Unit (ESE) is higher than 8.
4. Farms which are converted during the year are not included, whereas farms which converted during the year will fall in the category under conversion. The categories follow the definition based on the standard gross margin.

The main reason is the limitation in size. Analyses have shown that 523 farms are over a limit of 5 ha or 4 ESE, but under 10 ha and 8 ESE (number 3). Approximately 100 farms have converted during a year or their area differs from the Danish statistics (number 2). The remaining are either very small farms, under 5 ha, or farms here one part of the farm is organic and the other conventional.