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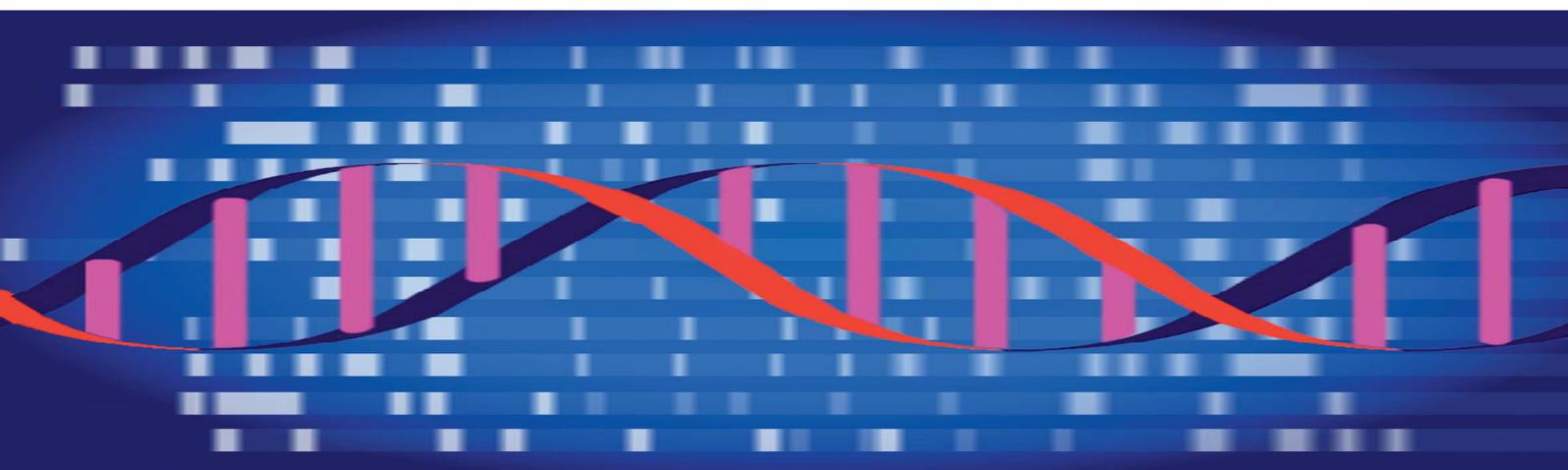
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Green Technological Foresight on Environmental Friendly Agriculture: Executive Summary



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Executive Summary

The Danish Forest and Nature Agency has initiated the Green Technological foresight on environmentally friendly agriculture with the aim of examining the agricultural environmental challenges and suggesting technological and structural solutions.

Agriculture can derive from 2004 until 2024 with or without dialogue; it can occur without any plan or with some thought. The Technological Foresight tries to create the background for a dialogue by synthesizing possible future directions on Danish agriculture with focus on the use of environmentally friendly technologies.

A premise that is necessary for agriculture to develop into an environmentally friendly direction is that research is undertaken into environmentally friendly technologies and methods and how they can be brought into use. There is a need for a prioritised research effort that focuses on those problems which are related to minimising environmental problems affected by the agricultural production's negative influence on the surroundings, improving animal welfare and finding new ways and products for agriculture.

More than Environmentally Friendly Technology

Environmentally friendly technologies alone do not secure future sustainable agriculture. There is a need for education and concepts that can make environmental and nature friendly technologies visible and thereby further them in the food production within which the agricultural production only accounts for the first stages.

Modern information technologies mean that there are unknown possibilities for sharing the information, which the manufacturers already have with the consumers. The great challenge is to provide it as precise, simple and usable as possible otherwise the consumers could quite easily drown in information.

In order to disseminate the environmental product-oriented effort, it is decisive to have one or more motivated factors for the manufacturers. This could be additional charges on products, market entry guarantee or improved production conditions. In addition, this incorporates continued efforts into strengthening the image of agriculture.

The greatest strength of the product-oriented environmental work is that it also plays a part in collecting and especially making visible the results of the work involving all the environmentally friendly technologies within the whole of the food manufacturing's product chain, thereby showing that it is the total effort in the chain which plays a part in reducing the environmental affects from the agricultural production.

Broad Dialogue regarding the Use of the Technologies

The Technological Foresight has been proposed in dialogue with a broadly combined panel of experts and agricultural players. The aim has been to present the environmental challenges of future agriculture to the technological options. There has been less focus on the need for protecting and further the value of nature in the

open landscape. The conversations have begun by drawing several possible diagrams of agriculture's future structure. Thus, agriculture can develop both in an intensive as well as an extensive direction. Two paths can be foreseen, which will mutual challenge each other in the future:

- *Industrial-Oriented Farming*: Intensive commercial activity where technologies first and foremost will be used with consideration to rational productivity, discard and effective environmental responsible solutions.
- *Organic-Oriented Farming*: The technologies are assessed in accordance with three central principles; cautionary, recirculation and subsidiary (see <http://www.darcof.dk/discuss/Princip.pdf>)

Future Farming

Future farming will orientate and base itself on knowledge and co-operation between farmers, research institutions and authorities. The aim of this co-operation is to create a dynamic and long-term farming policy. The consideration to the environment and the development of farming and nature-related values as well as optimal utilisation of resources could be seen as a basis for being able to compete internationally for farming products. The reason being that even though the international market will not immediately pay for investments into Danish environment, landscape and nature-related values, there is great potential for exporting the environmental technology to the international agricultural sector. A green image is at the same time a good sales argument at several more markets.

The future environmentally friendly farming technologies are assessed and chosen in accordance with their contribution on three areas where, for example, operating economical plans, green accounts and nature plans are treated equally.

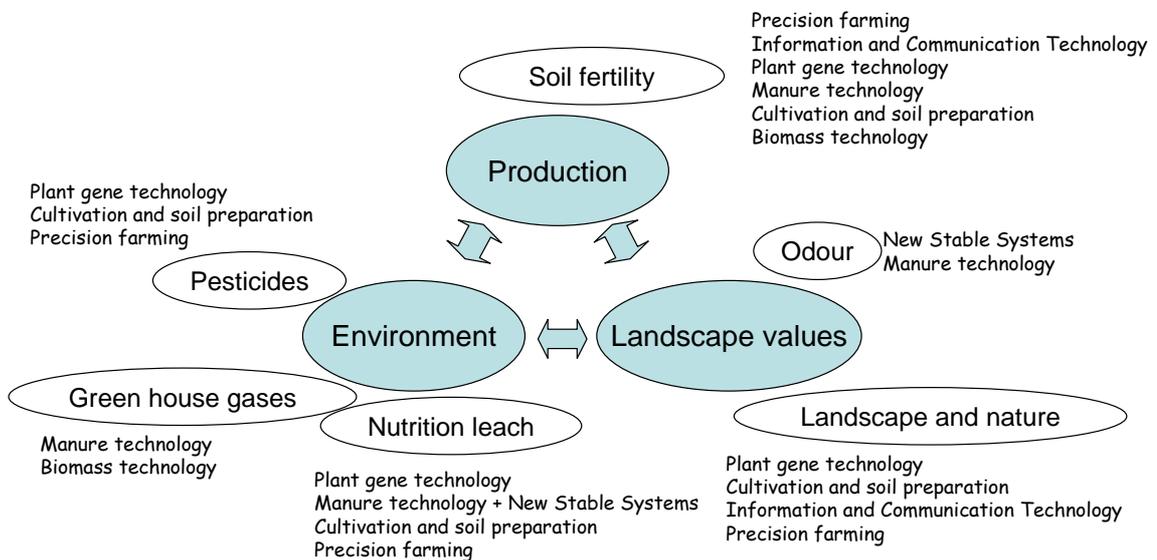


Figure: The Agricultural Triple Bottom Line. The figure demonstrates how the three bottom lines – production, environment, and landscape and nature values – constitute a unity when green technologies are selected for future agricultural systems

Production

The industry must be able to maintain a profitable and healthy plant and animal production. This is achieved by placing weight on technologies that ensure the soil's fertility, give operational economical advantages, ensure an improved quality of nutrition and feedstuff, and include energy crops and non-food crops.

The vision is:

- to create a balance between productivity and environment within current guidelines, which apply for both industrial and economical oriented farming
- to utilise nature's resources by using and combining new technologies that can further and retain the efficiency at the same time as the environmental strain is minimised
- to retain extensive operational potentials with a view to nature and landscape caring

Environment

The agricultural activities must be able to be carried out without negative consequences for the environmental physical frames, including space, water and air that can be influenced by wastage from agricultural production.

The vision is:

- to minimise the use of pesticides and other environmentally friendly substances by reducing weed, illnesses and pest problems with other measures than pesticides and use of manure on an environmentally friendly way
- to reduce farming contribution to the discharge of ammonia and greenhouse gases (methane, laughing gas, CO₂) through increased energy yields of foodstuff and fuel as well as the production of bio-fuel (biogas, ethanol, hydrogen)
- to minimise the loss of nutrients by an optimal utilisation and handling of manure in plant production by improved management of crop rotation, end harvesting, etc.

Landscape and Nature-Related Values

Agriculture needs to be part of managing and creating beautiful landscapes, versatile nature with many high quality habitats for wild flowers and animals, clean drinking water and recreational values. A continued gradual reduction of the farming space to intensive operation is expected and will in this way reflect those tendencies that have been known over the last 50 years.

The vision is:

- to remove odours from stables and in conjunction with manuring
- to increase the biological diversity in the field and its surroundings by a more or less precise use of pesticides as well as avoiding evaporation of ammonia from stables, animal manure storage and delivery
- to create an accessible nature, for example, through more intensive farming with a more varied natural content in the level of cultivation
- to re-establish natural areas including increasing forestry areas through redevelopment, removal and extension of farming areas

Potential Environmentally Friendly Technologies

The perspective for each technology is given in relation to production, environment and landscape and nature-related values.

Plant Gene Technology

Plant gene technology is controversial, but can when used carefully provide an increased and environmentally friendly production and contribute to landscape and nature-related values.

The perspectives for the technology are:

- to develop new farming products with increased market value based on vegetation that optimally use the Earth's and climate's resources
- to reduce the loss of nutrients by removing, reducing or changing vegetation's nutrient content, which can prevent an effective intake of foodstuff in domestic animals
- to create resistant crops that can influence an increased biological diversity in the field

Many of these advantages can be reached by molecular marker assisted breeding, i.e., a solution without the use of modification. The technology is thereby also interesting for organic farming. Plant gene technology has at this moment in time only a future if a varied dialogue regarding advantages and disadvantages where public scepticism about the technology is taken seriously. It is, therefore, necessary to soon take a policy decision with respect to the use of gene modified crops, including an approval procedure and labelling that considers the public's very broad perception of risks. The technology is still at a somewhat early stage and research programmes within genetic vegetation technology and risk shall, therefore, be upgraded.

Information and Communication Technology

The technology includes both decision support systems and a more efficient communication of the latest knowledge about environmentally friendly farming production. The technology does at the same time give completely new possibilities for supervising, modelling and controlling biological environments.

The perspectives for the technology are:

- that production data can be used in order to establish quantitative models of the biological system as well as decision support tools and management programmes that can be used by authorities and farmers so that they can make the best decisions;
- that the information about the animal and plant growth can provide the consumers with documentation showing that it concerns healthy and safe food products, which are produced environmentally friendly throughout the whole process "from soil to table";
- that a rational and efficient handling of data from the complex biological processes could be a deciding factor in a future knowledge-based food production.

The consumers' distance to the manufacturers means that the retailing link will play an important role when the consumers' demand for quality, food safety and environmentally friendly production is communicated down through the food production's many links.

Manuring Technology

Large amounts of ammonia are today discharged on the production of domestic animals. Nitrate is washed out when animal manure is fertilized that affects both eutrophication and increased production of laughing gas, which is a strong greenhouse gas. At the same

time, there is also often a too high content of phosphorous in the sludge in comparison with crop needs.

The perspectives for the technology are:

- to improve the management of nutrients and thereby improve the use of the resources within the domestic animal fertilizer;
- to lessen the nutrient load of the water environment as well as moors, commons and forests, etc.;
- to reduce odours from animal fertilizer storages and deliveries (de-gassing).

The integration of manuring technology with energy production is obvious, but it requires an increased research effort. There is also a need for the development of good systems that are compatible with agriculture's de-centralised structure and ensure an efficient logistical and reasonable economy.

Biomass Technology

Biomass technology is concerned with improving and developing technologies that can efficiently and cheaply change biomass to energy and industrial products with high value. The biomass technologies offer themselves to industrial as well as organic-oriented agriculture, but they are envisaged to be used on different centralised scales.

The perspectives for the technology are:

- to develop bio refinery in combination with biogas that can offer new products as well as improve the strength of flexibility and competition within the agricultural sector
- that agriculture can become the net producer of CO₂-neutral energy;
- to grow more low input energy plants that can increase the diversity of the farming landscape for the benefit of animal life
- that the production of biomasses within agriculture occurs in areas that do not have any significant value in respect of the protection of the water environment, wildlife (animal and plant) as well as the landscape and nature-related values
- to reduce the need for fossil fuel and thereby increase the supply safety and lessen the emission of greenhouse gasses by using biomass for power and heating production

Biomass technology is a complex system of technologies and products that combined have a potential of increasing the value of farming products. It is necessary to have an inter-disciplinary research effort wherein consideration is taken to the future energy infrastructure.

Cultivation and Soil Preparation Technology

Intelligent usage of biological and agricultural knowledge can be an efficient strategy for minimising the environmental effect of farming. This can be summarised by the term "good agricultural management", which can in the future be improved by using expert systems and advanced Information and Communication Technology for the promotion of the new knowledge.

The perspectives of the technology are:

- to reduce soil preparation and thereby gain savings on machinery and energy usage

- to improve better crop rotation and close loopholes in the nutrient circulation with catch crops in order to minimise nutrient loss
- to minimise environmental affects from fertilization and crop spraying with the help of integrating growth principles and knowledge usage

Diversity and recirculation are two fundamental principles in relation to growth technology in organic-oriented farming and increased focus on this within the industrial oriented farming can prove itself to be an important environmental gain. In order to take advantage of the potential of the technologies, it is necessary to have a considerable research effort to obtain more knowledge about the function and dynamic in agricultural ecology.

Global Position Systems (GPS) and Robots – Precision Farming

Precision farming is one of the options where the use of IT, sensors and robots can be utilised in order to adjust the production of raw material (plants and animals) to the specific areas' conditions or to the individual animal and plant needs for nutrients and care.

The perspectives of the technology are:

- to obtain savings in labour, improved management and more homogeneous crop quality
- to reduce the use and loss of nutrients and pesticides, together with other possible environmentally harmful products

The gain from precision farming within the highly developed agricultural systems can only be reached through optimising the whole of the production system. There is at the same time a need to develop software that can interpret the sensors' total data as area specific and measured allocation of pesticides and fertilizers.

Stable Systems

The reduction of odour and ammonia emission from stables is, together with animal welfare, working environment and efficiency demand, the largest challenge for animal production in Denmark. A green vision on the stable area consists, therefore, of the development of overall oriented and long-term solutions.

The perspectives of the technology are:

- to reach a better working environment and animal welfare in the stables
- to minimise the loss of nutrients and emission of gasses from stables and fertilizer storages
- to reduce odours from animal production

There is a need to develop and demonstrate completely new stables that use a wide range of different technologies and materials.

Choice of Technology within Industrial-Oriented and Organic-Oriented Farming

New technologies can be utilised in both forms of farming with a view to lessening the environmental effect. However, there can be a difference in how the technologies are used as the examples show in the Table. The technologies within organic farming are assessed in accordance with three principles: cautionary, re-circulation and subsidiary. Certain technologies, such as genetic engineering, are completely rejected by the organic

farming whilst diverted techniques can be used to improve organic crop processing (see tabel).

Examples of different future utilisation of technologies within the two links that can be envisaged for Danish farming.

| | Industrial-oriented farming | Organic-oriented farming |
|-----------------------|--|--|
| Genetic-technology | Total use of GMO, crossing of arts barriers. | Only utilisation of genetic markers in traditional processing. |
| Bio energy production | Straw and energy crop for centralised power stations, ethanol and RME factories. | Domestic animal fertilizer and N-fixing energy crop for decentralised biogas units or thermal gasifications. |
| Automation | Milking robots in stables. | Milking robots in the fields. |
