

## English summary

This report is about welfare economic and ethical evaluation of the use of genetically modified crops (GMC). These are in this connection limited to encompass plants that are resistant to herbicides, insect pests and plant diseases.

The purpose of welfare economic evaluation is explained and this evaluation method is compared to budget economic and national economic analysis. The welfare economic analysis is accomplished to assess how projects and other changes in the societies use of scarce resources affect the general welfare. The welfare depends on the consumption of marketed as well as non-marketed goods and services, e.g. environmental goods. Budget economic analysis on the contrary concentrates on the income consequences for different sectors of the economy. National economic analysis concerns the consequences for the gross domestic product and other national account measures. Of course these analyses are interdependent but the focuses of the analysis are different.

The first part of the welfare economic evaluation concerns description of the consequences of changes in the use of resources. The relevant consequences comprise:

- ◆ Resource use and environmental consequences in connection with the development and production of GMC
- ◆ Changes in resource use by using GMC compared to conventional or ecological agricultural production - including protection against gene dispersal to neighbouring fields and sales problems relating to the crops from these fields
- ◆ Changes in yield by using GMC compared to conventional or ecological agricultural production
- ◆ Environmental consequences of using GMC compared to conventional or ecological agricultural production

The consequences of using GMC are summarised in the table below.

	Conventional production	Herbicide resistance	Allelopathic substances	Insect pest /plant disease resistance	Stress tolerance	Ecological production
<i>Production</i>						
Yield		+			+	-
<i>Resource use</i>						
Sowing		+	+	+	+	
Fertilizer						-
Pesticide and herbicide use		-	-	-		-
Use of other materials				+		
Labour						+
Machines and buildings						
Protection of neighbouring fields and sales problems relating to the crops form these fields		+	+	+	+	
<i>Environmental consequences</i>						
Pesticide and herbicide loading groundwater		(-)	-	-	-	-
Pesticide and herbicide loading streams/lakes		(-)	-	-	-	-
Pressure on nature content of fields		(+)		(-)	(-)	-
Risk of gene dispersal		(+)	+	+	+	
Risk of toxic crop remnants in the field			+			
Risk of outstripping of other plants			+	+	+	
Health risk by eating the crop		?	?	?	?	-
Insecurity about unknown consequences		+	+	+	+	-

Note: + means "more" or "larger"  
 - means "less" or "smaller"

As the table shows it is necessary to distinguish between different kinds of GMC. Some GMC are resistant to herbicides. Others produce allelopathic substances that are toxic to weed. Still others are resistant to insect pests and plant diseases and finally some are stress tolerant. It is necessary to distinguish between these GMC's because their use results in different consequences with regard to yield resource use and environmental pressure. The table gives some tentative specification of these differences.

Generally GMC sowing use more resources than conventional and ecological production because it is costly to develop GMC. On the other hand using GMC saves resources for pesticide and herbicide use. This also means environmental advantages as ground water, streams and lakes are less heavily loaded with these compounds. The environmental disadvantages are related to the risks of gene dispersal and of outstripping of other plants. The risk of gene dispersal also

means that resources might be needed to protect the crops on the neighbouring fields and there might emerge sales problems relating to the crops from these fields. Last but not least the use of GMC might cause widespread feeling of insecurity among the population.

In welfare economic analysis these consequences are weighed together by use of so called accounting prices that indicate how much each consequence marginally affect human welfare. An indicator of this is the marginal willingness to pay for the consequence. The accounting prices for changes in the production and use of market goods can therefore be fixed on the basis of market prices. Such prices do not exist for environmental goods and therefore it is necessary to fix accounting prices for these goods by different direct and indirect methods. In this case the accounting prices indicate the marginal willingness to pay for changes in different living conditions that are affected by the environmental consequences of using GMC. These living conditions comprise the productivity of the environment as a production factor, recreational possibilities, health and aesthetical values.

The environmental consequences are

- ◆ reduced loading of groundwater with pesticides and insecticides
- ◆ reduced loading of streams and lakes with pesticides and insecticides
- ◆ changed nature content of fields and surrounding areas - these changes might both be positive because of the lesser use of pesticides and insecticides and negative because of different risks of gene dispersal, toxic substances in the fields and outstripping of other plants
- ◆ insecurity of possible consequences

Changes in groundwater quality might be priced in two ways, either as the costs of securing clean water supply or as the willingness to pay for the changes in health risks that are a consequence of changed water quality. This second way of pricing groundwater presupposes that the cause effect relation between changes in groundwater quality and health risks is known and that it is possible to fix the willingness to pay for changes in health risks.

The reduced loading of streams and lakes with pesticides is valuable to the society in several ways. First of all it means better recreational possibilities (e.g. fishing, botanizing) but other use values such as aesthetic value and option value might also be important. In addition to its use value the improved water quality might have a non-use value. To price these values it is necessary to describe how the changed loading affect the nature in and around the streams and lakes and on the basis of this description directly or indirectly fix the willingness to pay for these consequences. For instance the pricing of recreational possibilities presupposes determination of the number of people that will visit the different areas and of how much they want to pay for this.

The same approach can be used to price the changed nature content of the fields and the areas around these. Thus it is necessary to de-

scribe how the use of GMC affect the biodiversity of the areas compared to the use of pesticides and insecticides, what this means to the relevant welfare economic living conditions and finally how much people want to pay for this.

It is concluded that pricing of these environmental consequences involves many problems. These relate on the one hand to the cause effect description of the relation between changed pesticide and insecticide loading and the final consequences for the general living conditions comprising the productivity of the environment as a production factor, recreational possibilities, health and aesthetical values. On the other hand it is in itself very difficult to price these consequences.

The feeling of insecurity about possible unknown consequences is perhaps the most important consequence of using GMC, but it is concluded that presumably pricing of this insecurity is impossible. Thus it is not like risk possible to quantify insecurity and therefore it is not possible to price it either.

The insecurity about possible unknown consequences also gives rise to one of the important ethical questions about using GMC. Thus you might ask if it is permissible to expose people to risk and uncertainty without their own accept? You might also ask if use of GMC as well as use of pesticides and insecticides affect the living conditions of animals in a way that is ethical unacceptable? Further you might ask if the nature has inherent values that are threatened by the use of either GMC or pesticides and insecticides and if this is the case how you take this into account? Finally you might ask if ethical considerations could be expressed as deontological limitations on the use of the welfare economic basis of evaluation. This basis is ethical utilitarianism and it is well known that utilitarianism sometimes allows too much. So the ultimate ethical question is if the use of GMC should be evaluated on the basis of its welfare economic consequences (consequentialism) or if other ethical theories are more suitable.