ENGLISH SUMMARY

The present report from the Chairmen of the Danish Council of Environmental Economics contains three chapters about surface water, ground water and economic growth respectively.

Chapter I focuses on the Water Framework Directive and on the protection of the aquatic environment from nitrogen emissions, while chapter II deals with the protection of ground and drinking water in Denmark. These two topics have received much attention in the Danish environmental debate and environmental policy in recent years. Chapter I summarizes the Danish achievements in relation to the Water Framework Directive targets and also suggests a model for how nitrogen emissions can henceforth be regulated so as to minimise the costs of achieving good ecological status. Chapter II contains calculations for cost-effective protection of drinking and ground water against contamination by pesticides. In addition, the chapter contains a discussion on the taxation of water consumption.

Chapter III takes a more global perspective in assessing the relationship between the environment and economic growth. The focal point in chapter III is on whether nature sets limits to economic growth in the sense that either pollution or depletion of natural resources will cause economic growth, in the traditional sense, to cease.

Chapter I: The Water Framework Directive and Regulation of Nitrogen Emissions into Coastal Waters

Under the Water Framework Directive Denmark, along with all other EU member states, is committed to achieving good ecological status in all water bodies by 2015, however, the Directive provided for the possible extension of the deadline to 2021 or 2027. Chapter I summarizes the Danish goal attainments, with a special focus on nitrogen emissions

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from agriculture into coastal waters. The chapter considers the regulation of nitrogen from both a theoretical and applied point of view, exemplified through a case study of Denmark's largest river basin district, Limfjorden. These considerations lead to a proposal for new Danish nitrogen regulations. The proposed regulations aim to minimize the welfare economic costs of meeting the goals of the Water Framework Directive for Danish coastal waters.

Attainment of the goals in the Water Framework Directive

Despite improvements in the status of Danish water bodies, only 2 per cent of coastal waters have thus far achieved the goal of good ecological status. For rivers and lakes the goal is achieved for 28 and 22 per cent, respectively. It is expected that just over 40 per cent of coastal waters and rivers and 25 per cent of lakes will meet the goal by 2021 under the policies already in place. Hence, increased effort is needed in order to reach the goal of good ecological status in all water bodies.

The improvement in the ecological status of coastal waters will be achieved through a reduction of nitrogen emissions. However, the deadline for fulfilling the goal has been postponed several times. The longer the ecosystems deteriorate, the harder it is likely to be to reach a good ecological status. If the deadline for fulfilment is postponed even further, the effort needed to achieve good ecological status may be even greater and more costly.

A greater effort is required to reach the common goals of the Water Framework Directive in Denmark than in other similar countries. This is in part due to geographical conditions, as Denmark has a long coastline and a large share of coastal waters in relation to its land area, compared with e.g. the United Kingdom, the Netherlands and Germany. The most important reason, however, is the intensive agricultural production, as almost 60 per cent of Denmark's area is cropland. Consequently, nitrogen from the agricultural sector is the most important source of pollution in Danish coastal waters. In addition, many of the coastal waters are naturally sensitive, as there is relatively little influx

from open waters, and small river basins release nitrogen swiftly from the land to the coast.

The Directive contains provisions for exemptions from meeting targets in cases where the costs of doing so are disproportionately large (the disproportionality principle). The large reduction in nitrogen emissions needed to reach the goal of good ecological status in Danish coastal waters makes it particularly relevant for Denmark to consider whether the costs are disproportionate. Such a consideration should, to the greatest possible extent, be based on a quantification of the benefits of reaching a good ecological status in order to enable a comparison of costs and benefits. It is therefore recommended that the Danish authorities emphasize the assessment of the benefits of reaching a good ecological status in coastal waters.

In the most recent river basin management plans, currently subject to public consultation, a large number of reduction goals are postponed until after 2021 on the basis of disproportionately large costs. It is not, however, clear which criteria have been used to assess the disproportionality of the costs. From a welfare economic perspective, the fact that reaching an environmental objective is costly is not a sufficient criterion to determine whether reaching that goal is advisable or not. To justify the use of the disproportionality principle, the costs should greatly outweigh the benefits.

Regulation of nitrogen emissions

There is great geographical variation in the soil's ability to retain nitrogen and other nutrients (the soil's *retention*). A reduction in the amount of nitrogen applied to a low retention field reduces the emissions to the coastal waters by more than the same reduction on a high retention field. Targeted nitrogen regulations reduce the use of nitrogen on fields where the effect is greatest. Therefore, targeted regulations will enable the achievement of good ecological status at a lower cost than general regulations that impose a proportional reduction in nitrogen use on all fields.

The chapter contains a case study of the costs of reducing nitrogen emissions into Limfjorden through different measures. The case study is carried out in cooperation with the Department of Environmental Science/Danish Centre for Environment and Energy at Aarhus University. The analysis shows that it is 20-30 per cent more expensive to reduce emissions through general regulation than through targeted regulation. Previous Danish studies have found the gains from targeted regulation to be of a similar magnitude.

The present nitrogen regulations in Denmark use a nitrogen allowance system. The allowance granted to each farmer is the private economically optimal amount of nitrogen for a given crop on a given field, less a certain percentage that is the same for all. The subtracted percentage is neither dependent on the choice of crop, nor on the retention of the land. Hence, a farmer cultivating a crop that requires much nitrogen is allowed to use more nitrogen than a farmer growing a less nitrogen-demanding crop. This is not an appropriate regulation, as it increases the welfare economic costs of reaching a given reduction target.

The current nitrogen allowance regulation does not give any incentive to reduce nitrogen use on sensitive fields with low retention, from which most of the nitrogen is released into the coastal waters. In principle, targeted regulations that take into account the soil retention and choice of crop in the calculation of each farmer's nitrogen allowance could be introduced. However, differentiation of the nitrogen allowances would give rise to private economic benefits from circumventing the regulations. It would become profitable to transfer nitrogen from fields that have a large allowance to fields with a smaller allowance. Controlling for such sidestepping of the regulation is difficult, and consequently, differentiated allowances would be difficult to enforce.

The model calculations for the Limfjord river basin indicate that differentiated nitrogen allowances are not an important instrument for minimizing the costs of nitrogen reduction, at least not when other targeted instruments are available. Thus, differentiated nitrogen allowances are not advisable.

Proposal for future regulation

Due to the inadequacy of the current nitrogen allowance system and the enforcement issues related to differentiated allowances, it is recommended that the nitrogen allowance system be removed and replaced by a general tax on nitrogen. A nitrogen tax will achieve a given emission reduction in a cheaper way than the allowance system, as it will both give an incentive to lower the overall use of nitrogen as well as to choose crops that are less nitrogen-demanding. Furthermore, a nitrogen tax is far simpler to administer than the current nitrogen allowance system.

A general tax on nitrogen can achieve some of the reduction necessary to reach the goal of good ecological status. However, as the reduction requirements differ geographically, additional targeted measures are required to fulfil the goal. It is therefore proposed that a market for quotas on emitted nitrogen to the coastal waters in each of the 23 Danish river basin districts be established. The number of quotas in each district should reflect the level of emissions compatible with the objectives of the Water Framework Directive. Each farm must acquire a certain number of emission quotas to cultivate a given crop on a given field. The emission quotas can be understood as crop cultivation permits, whereby the required number of quotas reflects the calculated emissions to the coastal waters from cultivation and, thus, the environmental damage.

An illustrative example of the number of required quotas can be made for two equally sized fields, A and B. The only difference between them is the retention of the soil, which is 0.8 for field A and 0.2 for field B. From field A, 20 per cent of the nitrogen leaching from the root zone will end up in the coastal waters. For field B, 80 per cent of the leached nitrogen will end up in the coastal waters. To cultivate the same crop, the owner of field B has to buy four times as many quotas as the owner of field A. Thus, the number of

required quotas depends on the retention of the soil and the nitrogen surplus of the crop.[1]

Such tradable emission quotas will make it more costly to cultivate crops with a large nitrogen surplus on fields where much of the nitrogen ends up in the coastal waters. This will give an incentive to redistribute the crops geographically, so that nitrogen-demanding crops are cultivated in fields that retain most of the applied nitrogen. On fields where much of the nitrogen ends up in the coastal waters, there will be an incentive to cultivate crops with a small nitrogen surplus, or to take the field out of cultivation. The transferrable quotas can also encompass other area-specific measures, such as catch crops, energy crops and the creation of wetlands.

It is therefore proposed that future regulation of nitrogen be conducted through a combination of a general tax on nitrogen and tradable emission quotas, which reflect the nitrogen burden of cultivation. These two instruments should replace the current nitrogen allowance system. The given number of emission quotas can either be auctioned by the state or granted to the farmers prior to being traded. These alternatives will not affect the cost-efficiency of the regulation, but will have different distributional implications. Replacing the nitrogen allowances with a nitrogen tax will generate tax revenue. In case there is a political desire to make the reform cost neutral, the revenue from this tax could be returned to the agricultural sector.

Chapter II: Groundwater, Drinking Water and Pesticides

Clean water is important to the health of humans and nature. Denmark differs from most other countries in that the supply of drinking water is almost entirely based on groundwater that does not need to be purified of pesticides.

1) The nitrogen leaching from the root zone primarily to groundwater depends, among other things, on how much nitrogen is fixed in the harvested crops and in the organic matter in the soil.

Overall, there are two different potential environmental problems associated with groundwater. The first concern is contamination of groundwater by, e.g., pesticides and nitrates. The second is excessive abstraction of groundwater, which is an issue in parts of Denmark.

Regulation of the use of pesticides

In the preventive efforts great emphasis has been put on reducing the risk from pesticide use. Since the first national Action Plan on Pesticides in 1986, Denmark has set targets to limit the use of pesticides. However, the targets for agricultural use of pesticides have not been realized.

The amount of pesticides in the groundwater has increased over time. This development should, however, be interpreted with caution, as the number of pesticides tested for has also increased during the same period. In addition, the majority of these pesticide findings were related to pesticides that are banned today. Pesticides were identified in more than 40 per cent of monitoring points in Danish groundwater in 2012, and the drinking water requirement of 0.1 µg/l was exceeded in 12 per cent of monitoring points.

The environmental impact of pesticide use is characterized by the fact that the harm to the groundwater reserves of using pesticides varies geographically, because different areas have different geological properties. Geological variation means that some groundwater reserves are more exposed to pesticide contamination than others. This calls for a mixture of policy measures to regulate the use of pesticides. The range of policy measures includes taxation of pesticides, a general ban on certain types of pesticides and local bans on the use of pesticides in certain areas. The advantage of a tax is that it reduces the incentive to use pesticides while allowing the user flexibility. However, in the case of particularly harmful pesticides, a general prohibition is more suitable, as the benefits of using these pesticides are never commensurate with the damage they inflict on the environment. Likewise, local bans on pesticide use in particularly pesticide sensitive areas may be more appropriate than a general ban on all pesticides.

The Danish pesticide tax was changed in mid-2013. The new tax depends on the environmental and health impact of pesticides, implying a higher tax on the more environmentally hazardous pesticides. Overall, this is a sensible change, which is also consistent with previous recommendations from the Chairmanship of the Economic Council.

Parts of the agricultural area in Denmark are more sensitive to pesticides, because there is a greater risk that pesticides applied in these areas end up in the groundwater, or because the areas are close to drinking water wells. This chapter presents a new analysis of the economic costs of four different area management measures to protect the groundwater in various pesticide sensitive areas throughout Denmark. The four area management measures are:

- Afforestation
- Open natural landscapes
- Organic farming
- Pesticide-free farming

The analysis calculates the socioeconomic costs of implementing such initiatives in a number of specific case areas with agricultural production. The calculation of economic costs includes loss of earnings in farming as well as benefits in terms of reduced pollution (fewer greenhouse gas emissions and better surface water environment) and increased recreational benefits from afforestation and the establishment of new open natural landscapes. The benefits of mitigating the risks from pesticides in groundwater are difficult to determine and have therefore not been included in the analysis.

The analysis shows that afforestation and establishment of open natural landscapes are the socioeconomic best area management measures. The benefits in terms of increased recreational value and reduced emissions of greenhouse gases and of nitrogen to the aquatic environment overshadow the costs in terms of lost earnings from farming. In addition to protecting drinking and groundwater in pesticide sensitive areas, these measures provide a benefit in themselves.

There is geographic variation in the benefits of afforestation or the establishment of open natural landscapes. The benefits are highest near larger cities. Therefore, it is recommended that area management measures be implemented initially close to major cities.

The calculations were made for 50 different "case areas", which together represent only a very small part of Denmark (0.1 per cent of the land area). The recreational value of additional forest or natural landscapes will, however, diminish if these measures are implemented on a large scale. The fact that there are large economic benefits from afforestation and open natural landscapes on a small scale, does not automatically imply that there are the same economic benefits from afforestation and open natural landscapes on a large scale.

Approximately ⅓ of the municipalities in Denmark have already identified, or are in the process of identifying, sensitive areas located close to drinking water wells. Identifying pesticide sensitive areas is a precondition for the effective use of area management measures. It is therefore recommended that the identification process be accelerated.

Regulation of groundwater extraction

Excessive extraction of groundwater can have negative effects on water bodies and affect flora and fauna, as well as increase the risk of (natural) contamination of groundwater resources. There is geographic variation in the external environmental cost of extraction. The extraction of water is greater than the sustainable level in the Copenhagen metropolitan area and in other parts of Zealand, while extraction in large parts of Jutland is relatively low compared to the sustainable level.

Danish taxes on the consumption of water should be set at levels that correct for the negative externalities of excessive extraction in a given region. For instance, since the relationship between the extraction and the sustainable level of groundwater varies geographically, so should the tax on water. However, current taxes on water do not reflect these

negative effects, as a uniform tax is charged throughout Denmark.

No analyses have been made of the marginal external cost of extraction that can be used to accurately determine the appropriate level of tax on water in different parts of Denmark. But based on the knowledge available, it is assessed that the tax should be raised significantly in regions where extraction is higher than the sustainable level and vice versa.

Some expenses related to protecting drinking water are financed through the price of water, partly by a temporary earmarked tax and partly by including the costs of certain preventive measures. This coupling between the price of water and the financing of pollution abatement is not appropriate. The level of environmental taxes should only reflect environmental impacts and environmental targets and not reflect a need for financing. If expenses related to pollution control are financed by a charge on water, it will lead to an unintended distortion of water consumption. It is, therefore, recommended that the current (temporary) earmarked tax not be renewed and that the activities funded by this tax instead are included in the general prioritization of public spending.

Chapter III: Economic growth and the environment

Economic activity draws on natural resources and causes pollution, and it is necessary to take account of these factors. Thus, one of today's key economic questions is whether nature sets limits on economic growth in the sense that either pollution or depletion of natural resources will diminish or eliminate further growth in real GDP in the future. This is the central question in chapter III.

A general perception among the public is that continued economic growth is associated with higher pressure on nature in the form of more pollution and/or greater natural resource use. However, economic growth does not necessarily imply a greater consumption of resources or more harmful emissions. Economic growth measures the increase

in the value of what we produce, and the value of our production may rise even if the purely physical input of natural resources, measured in, e.g., tonnes or kilojoules, is constant or falling. Changes in consumption patterns and technological progress will help to conserve resource use without necessarily requiring lower real wealth.

Environmental impact on economic growth

Continued economic growth with a fall in (or at least constant) resource use and pollution is possible if substitutability between natural inputs (resources in the broad sense, including the environment) and man-made inputs is sufficiently good. Thus, substitution possibilities are a central keyword for the issue of sustainable growth.

A very important mechanism to ensure that substitution possibilities are used is that the increasing scarcity of resources leads to rising prices of the resource. Increasing prices will contribute to savings on the use of resources in production and consumption. At the same time, price increases will provide an incentive for research and development of alternative products and production methods that use fewer resources. Rising prices of scarce natural resources will also increase the incentives for recycling and make exploration for new finds more profitable.

Although the price signals are important, we cannot be confident that rising prices will be able to resolve problems of resource scarcity in all cases and in the indefinite future. It depends on how good the basic future substitution options are. The future substitution possibilities are inherently unknown. It is, therefore, not possible to exclude that resource scarcity will prevent further growth or even lead to falling production one day. However, the experience for most important resources so far has been that substitution possibilities, in the broad sense, including the use of new technology and the appearance of new discoveries, have been sufficiently good for economic growth to be maintained.

Thus, the problem of scarcity of natural resources has so far not been of acute importance. Among other things, new

discoveries of many natural resources have meant that the remaining reserves have not decreased despite the fact that resources are consumed. For example, in 1980 it was estimated that the global oil reserves would stretch to 30 years of continued consumption. In 2013 the equivalent estimate was over 50 years. Continued technological research and development, partly due to the expectation of rising prices, has contributed to the increasing reserves of oil, despite a significant increase in consumption in the intervening period. Similar upward revisions of the remaining reserves have happened to many other resources.

The impact of growth on the environment

Climate change is probably the most important environmental problem facing the world at the moment. Calculations in the chapter using the economic climate model DICE indicate that there is a need for significantly more stringent climate policies at a global level than exist today. In the baseline scenario presented, where the level of ambition for global climate policy is not changed compared to today, the temperature rises to six degrees above pre-industrial levels in a few hundred years. To comply with the objective that the average global temperature must not rise more than two degrees, greenhouse gas emissions must be reduced. According to calculations in DICE, the necessary reduction in emissions could be achieved by the introduction of a global tax of 50 dollars per tonne of CO_2 in 2015. This corresponds to an eightfold increase in climate action compared to today. According to DICE calculations, the tax would have to rise further over the coming decades and must be over 270 dollars in 2060.

Although there are costs associated with an ambitious climate policy, they are far from a magnitude that prevents continued growth in global GDP. The DICE calculations show that cost-effective fulfilment of the two-degree target will lead to global GDP being 2½ percent lower in 2050 and almost 1 percent lower in 2100 than in a situation where the level of ambition in climate policy is not changed compared to today. When taking into account the economic value of the climate damage that is avoided by living up to the two-

degree target, the cost in 2050 is reduced to around 2 percent, and there will be a net gain of 1 percent by 2100 compared to the laissez-faire scenario. These effects can be described as rather small compared with the increase in per capita consumption; in the baseline scenario the increase in consumption per capita is over 400 per cent from 2010 to 2100. While there is great uncertainty associated with such model calculations, the results are confirmed by a number of other calculations and considerations, including the UN's Intergovernmental Panel on Climate Change.

Calculations based on the DICE model indicate that reducing global CO_2 emissions bring improvements to welfare. Based on the standard assumptions in the model, the two-degree target is too ambitious. The model, however, involves only a limited risk of extreme disaster scenarios and the trade-off between current and future generations' welfare is also debatable. All these factors indicate that the baseline results in DICE are on the optimistic side in terms of the need to prevent future climate damage. Taking this into account, the two-degree target can be perceived as an appropriate compromise between the interests of a continued increase in material wealth and the environment.

In most countries the production consists increasingly of services and to a lesser degree of physical goods. Thus, changes in the industrial structure contribute to a relatively minor drain on natural resources. Of the total increase in Danish GDP of 40 per cent since 1990, about 90 per cent is due to growth in the private and public service sector. Only one-tenth of the growth comes from the manufacturing industry and primary sectors.

Changes in the composition of demand and the industrial structure are important for the consumption of materials and natural resources. While total production in Denmark during the past 20 years, as mentioned, increased by about 40 per cent, there has only been a small increase in the total physical material consumption measured in tonnes over the same period. The increase in material consumption calculated in tonnes is, however, mostly due to an increase in consumption of heavy construction materials such as sand and grav-

el. On the other hand, the consumption of metals, fossil fuels, etc. has decreased. These developments show that economic growth is not necessarily accompanied by use of extra materials.

It is debatable whether it is appropriate that politicians set targets to reduce resource consumption. Concern for resource scarcity is an often used argument for governmental interference. Basically, increasing scarcity of resources, however, leads to rising prices, which gives incentives to reduce consumption. The government should only intervene if there are identifiable market failures in the price formation, or if the use of the resource leads to negative impacts on the environment that are not taken into account in the price of the resource. In such cases, we should work to resolve the issue at a global level, since a single country or a small region can only do very little to affect global supply and demand for resources.

GDP growth is not in itself a particularly good measure of the development of national welfare and quality of life. There are many well-known reasons for this. It is, therefore, concerning to have an unconditional political objective to maximize GDP without taking the possible costs of this growth into account. These costs are, for example, loss of leisure or a deterioration of the environment, health, distribution etc., which may also have important implications for people's welfare. It is important to be aware of these trade-offs when demands for action that may lead to a higher GDP are discussed.

However, in many respects, GDP plays, for practical reasons, an important role as an indicator of a country's economic success. Since what you measure affects what you do, it may have the consequence that there will be a bias towards too much emphasis on material wealth compared to other conditions.

In recent years there has been a growing recognition that it is important to develop more nuanced objectives, which cover various aspects of people's welfare better. Not least, the Stiglitz-Sen-Fitoussi Commission, which was set up by

French President Sarkozy, has put this aspect on the agenda. Therefore, it is positive that on an international level there is much work being done to develop better indicators of sustainability and green accounts. Goals such as genuine savings that involve several aspects other than those covered by traditional savings concepts can be seen as part of this development.