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COST-BENEFIT ANALYSIS OF THE SKJERN RIVER RESTORATION PROJECT

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PREFACE

The present cost-benefit analysis of the Skjern River Restoration Project was conducted on behalf of the Danish Forest and Nature Agency as part of the investigations by the Wilhjelm Committee, which was appointed by the Danish Government in March 2000. The Committee's assignment was to establish the scientific basis for formulating a national action programme for biological diversity and nature conservation in Denmark. The present text is a translated - and extended - version of a report on the same subject, delivered to the Danish Forest and Nature Agency, on October 25th, 2001. The addition consists of Appendix II dealing with theoretical and methodological aspects of economic valuation and cost-benefit analysis.

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Copenhagen, February 2002.

1. INTRODUCTION

Society is using a considerable share of its resources for the production of public benefits and services, which are not traded in a market – and therefore evaluated at market prices. Consequently, the market mechanism does not ensure that resource use in these sectors is efficient. During the second half of the twentieth century, methods for economic assessment of the social efficiency of public investment projects were developed. These methods are now referred to as *cost-benefit analyses*. Until 2-3 decades ago the use of cost-benefit analyses was limited to expensive public sector undertakings, primarily large scale infrastructure projects. Generally, environmental benefits were not included – at least not in monetary terms.

Yet, it is not only man-made goods that provide social benefits. The environment represents a supply of resources, whose continuous contribution of services is essential to human welfare. For this reason society allocates a considerable amount of labour and capital to pollution control and environmental protection. Likewise, a certain share of farmland and forest areas are being used primarily for environmental purposes. Despite the considerable costs of environmental policy, cost-benefit analysis is not generally applied in the political decision-making processes – at least not in Denmark.

Over the last 3-4 decades economic valuation methods have been developed. The purpose is to provide a basis for economic efficiency assessment of environmental policy and projects in the form of cost-benefit analysis etc. USA is leading in this area: Here, economic valuation and cost-benefit analysis are integrated in the political decision-making process. Recently, the Danish Economic Council and the Ministry of Finance have suggested that this type of economic analysis become part of the political decision-making process in Denmark as well.

Recently the Wilhjelm Committee - charged with drafting a national action programme for biodiversity and nature protection - commissioned a study of the theoretical basis for economic valuation of biodiversity, along with a number of cost-benefit analyses of nature restoration projects. The present report describes one of the cost-benefit studies that of the Skjern River restoration project. The report is an extension of a more general account of the theoretical and methodical basis for economic valuation and cost-benefit analysis of environmental benefits (see Dubgaard et al., 2001).

The purpose of the Skjern River study is to compare the social benefits and the social costs of the project. The analysis includes market benefits as well as non-market benefits. The value of non-market benefits is calculated using economic valuation methods or transfer of benefit estimates from foreign studies. The analysis incorporates the existence value of increased biodiversity, the use value of improved possibilities for outdoor recreation, angling and hunting, as well as the purification effects of retaining ochre and nutrients etc. The cost side comprises the loss of land rent associated with a change in land use, along with project investments and costs of operation.

2. BACKGROUND AND ASSUMPTIONS

2.1 Purpose of the Skjern River project

The primary purpose of the Skjern River project is to re-establish a large coherent nature conservation area with good conditions of life for the fauna and flora connected with wetlands and riparian areas. The project comprises approximately 2,200 hectares (ha), where the following initiatives will be carried out (Danish Forest and Nature Agency, 1998):

- Restoration of the lower 20 km of the Skjern River toward Ringkøbing Fjord
- Establishment of a lake of app. 160 ha in the Hestholm area
- The River will be laid out with several outflows to the Fjord, which, in time, will create a delta of app. 220 ha
- Re-establishment of the contact between the River and riparian areas by permitting periodical floods on 290 ha of reed covered land within the project area
- Transfer of 1,550 ha of arable land to extensive grazing.

Extensive studies of the physical, chemical and biological aspects of the project have been conducted previously (see National Environmental Research Institute, 1997; COWI, 1997; Danish Forest and Nature Agency, 1998). The following is a brief survey of the biological effects.

2.2 Biological effects of the Skjern River project

As mentioned previously, the overall objective of the Skjern River project is the re-establishment of a large coherent nature area. The project will improve the water quality of the Skjern River system, living conditions for the wild flora and fauna, together with the recreational value of the area. In addition there will be positive biological effects in Ringkøbing Fjord due to the retention of nutrients and ochre in the wetlands of the river valley. The size and position of the various nature and semi-nature areas are shown in table 1.

Table 1: Land use in the project area after nature restoration

Area characteristics	Area, ha
Open water and water courses	200 (9%)
Reed	420 (19%)
Dry meadow	480 (22%)
Wet meadow	815 (37%)
Pasture	285 (13%)
Total	2,200 (100%)

Source: Own calculations based on COWI (1997).

2.2.1 Flora and Fauna

The project will improve the conditions for the wild flora and fauna considerably. The flora of riparian areas and the River will become more diversified and is expected to include rare species like Elisma natans in flowing water and calamus, water soldier and cowbane in still water. The area will become increasingly attractive to breeding and resting birds, particularly species with attached to wetlands, reed, and meadows. A significant factor is the establishment of a large coherent area with improved possibilities for nesting and feeding. Bird species like kingfisher, bittern, water rail, crake, reed bunting, reed warbler, bearded tit, ducks and geese are expected to breed in the area. In addition to a varied bird life, an increase in the population of endangered amphibian and reptile species is expected. The otter will supposedly re-immigrate from populations in central Jutland as man-made barriers in the landscape are either removed or remedied by fauna passages.

Improved water quality, environmentally friendly maintenance practices, and the re-establishment of spawning grounds will have a positive effect on the salmon and trout populations in the River. Furthermore, a river with turns and deeper parts, combined with stretches of fast flowing water, will increase the number of shelters and a large occurrence of prey.

Core areas free from hunting and disturbance will be established to ensure resting, foraging, and breeding possibilities for birds and mammals. Large flights of ducks have already been registered and the populations of migrating and resting birds are expected to increase. This will mean improvement of hunting opportunities, inside as well as outside the project area.

2.2.2 Purification effects

The Skjern River project will reduce nitrate, phosphorous, and ochre pollution. The reduction is attained partly by the transfer of arable land to extensive uses, partly by the creation of a delta, which, together with other periodically flooded areas, will re-create the natural ability of the soil to filter nutrients and other particles. Thus, the project will result in a considerable reduction in the load of nutrients and ochre in Ringkøbing Fjord, where the impact of these substances has been heavy.

2.2.3 Recreational value

The nature restoration project will considerably increase the possibilities for recreational use of area. The size of the project area facilitates activities such as hiking and biking, boating, camping, studies of flora and fauna, angling, hunting etc. Accessibility will be improved by the establishment of new trails, access to grazing areas and construction of outdoor recreation facilities.

2.3 The cost-benefit analysis - objectives and methods

The purpose of cost-benefit analysis is to provide a basis for making decisions, which contribute to ensure the most efficient use of society's scarce resources. In a cost-benefit analysis all quantifiable consequences of a project are measured in monetary units, and the project is assessed in terms of the net present value of costs and benefits. A social cost-benefit analysis should - to the greatest possible extent - incorporate market as well as non-market costs and benefits. A project is considered to be socially advantageous, if the sum of discounted consequences (benefits and costs) is positive. See appendix II for a more comprehensive discussion of the principles underlying cost-benefit analysis.

2.3.1 Modifications relative to previous cost-benefit analysis

In 1998 COWI (a consultancy firm) conducted a cost-benefit analysis of the Skjern River project for the Danish Forest and Nature Agency. The essential differences between the present cost-benefit analysis and COWI's are different environmental assumptions, an extended database for the quantification of recreational benefits, and a broadening of the benefit side to include the existence value of increased biodiversity.

As for the welfare economic assumptions, the present analysis follows the recommendations in Møller et al. (2000). Thus, costs and benefits are calculated in market prices (the COWI analysis used factor prices). EU subsidies to agriculture are classified as an income for the Danish society (rather than transfer payments) and as such incorporated in the analysis as benefits. In COWI's cost-benefit analysis EU subsidies were excluded.

As mentioned before, the benefit side is extended to include an estimation of the existence value of enhanced biodiversity. The existence value is quantified through transfer of benefit estimates from a similar project area in the UK. Use values include improved opportunities for outdoor recreation, hunting and angling. The benefits of outdoor recreation are estimated by transferring willingness to pay estimates from a valuation study of Mols Bjerge (a landscape of outstanding natural beauty in East Jutland). Visitation estimates are based on registered visit frequencies in similar areas. The value of improved angling opportunities is estimated through benefit transfer from a study of anglers' willingness to pay in the Nordic countries. Benefits from improved hunting are calculated from data on the rental value of hunting rights in areas with habitat characteristics similar to the restored Skjern River valley. The projects purification effects with respect to nitrogen, phosphorous and ochre are evaluated as the opportunity costs of alternative purification measures.

As for the cost side, detailed calculations have been made of the loss of land rent due to the transfer of arable land to other uses. It is taken into account that (in the absence of the project) part of the arable area would have been marginalized due to settling of drained land.

2.3.2 Use and non-use values of ecosystems

Human use (direct or indirect) of the ecosystem's services implies, that these must be considered economic values. The essential value categories are:

- Value as a factor of production (farm land, fish stocks etc.)
- Input in consumption (hunting, angling, wildlife observation and outdoor recreation)
- Ecological benefits (e.g. retaining nutrients and binding CO_2)
- Option value (benefits from having the possibility of using a given resource)
- Existence value (satisfaction from knowing that species and ecosystems exist)
- Bequest value (satisfaction from considering the interests of future generations).

A large number of these services are non-market benefits. Thus the economic value must be uncovered by measuring people's (hypothetical) willingness to pay for the benefits in question. See appendix II (2-4) for a more detailed discussion of economic value and environmental goods.

2.3.3 Valuation and pricing methods

There are different theoretical approaches to monetarization of non-market goods; preference based and non-preference based, respectively. Economic valuation as such is based on preference revelation – attempting to measure people's willingness to pay for non-market benefits. Willingness to pay reflects the relationship between price and demand – a relationship, which, in theory, one would be able to observe, if the goods in question could be traded at a market. The valuation studies employed in this analysis are based on the Contingent Valuation Method (CVM). The method sets up hypothetical markets for the procurement of e.g. environmental benefits. Randomly selected respondents are subsequently questioned about their willingness to pay, e.g. for a specified increase in the biodiversity of a particular area.

There are also a number of non-preference based methods available for monetarizing non-market benefits. These methods can be described as pricing. Pricing methods are usually somewhat easier to apply than actual valuation methods. But the monetary estimates obtained are not necessarily in agreement with the value concepts of welfare economics. Consequently, such estimates may not provide (theoretically) correct measures of the social benefits from environmental policy initiatives. However, in the absence of valuation studies, pricing may often be considered an acceptable alternative. This report uses the opportunity and purification cost methods for pricing various benefits. The opportunity cost method prices benefits as the costs of obtaining the same effect through the best available alternative, whereas the purification cost method evaluates the benefits as the treatment costs associated with alternative purification process.

See appendix II (6.1-6.3) for a description of pricing and valuation methods.

2.3.4 Transfer of benefit-estimates

Conducting economic valuation by state-of-the-art criteria is both time-consuming and expensive. This has lead to an increasing interest in reusing the results of previously conducted valuation studies - commonly referred to as benefit transfer. Benefit transfer implies that valuation estimates or valuation functions from a research area (i.e. an area, in which a valuation study has been conducted) are transferred to a project area (i.e. an area, where one wishes to assess a project, prior to an actual implementation). Naturally, greater uncertainty is connected with this form of valuation. Still, benefit transfer is recommended as an acceptable solution by the British and American environmental authorities, among others (see U.S. EPA, 2000 and U.K. Treasury, 2000). Preferably policy-analyses should be based on data collected through primary research. However, it seems possible to get a fair impression of the magnitude of environmental benefits through benefit transfer. Appendix II (Section 7) gives a more comprehensive description of benefit transfer methods.

2.4 Assumptions underlying the cost-benefit analysis

The following is a brief survey of the hypotheses and assumptions of the present cost-benefit analysis.

2.4.1 Timeframe

The year 2000 has been chosen as the base year. Benefits and costs occurring before the base year are inflated to year 2000 prices (using the wholesale price index) and imputed capital costs (interest) are added. Future costs and benefits are discounted to present value. Because environmental benefits do not decrease with time, but continue indefinitely, an eternal time horizon is used. Calculating values over an indefinite time horizon is associated with great uncertainty. Therefore, the analysis is also made for a time horizon of 20 years. The primary reasons for this sensitivity analysis, are the uncertainty concerning the development in farm subsidies (the EU-subsidy), and marginalization tendencies in the project area due to the composition of the soil.

2.4.2 Discount rate

The choice of base year implies that project effects before 2000 must be inflated and imputed interest added, whereas future effects must be discounted. No agreement exists as to what the appropriate level of the social discount rate should be (see appendix II.5 for a discussion). In the present cost-benefit analysis, discounting is conducted within the span of social discount rates suggested in Denmark, i.e. 3%, 5% and 7%.

2.4.3 Calculation prices

All benefit and costs are measured in market prices (i.e. including taxes and levies). This is due to the fact that market prices form the basis for consumers' selection of various consumption alternatives, including the willingness to pay for environmental benefits. Most of the project costs, however, are given in factor prices (i.e. without taxes and levies). It is necessary, therefore, to raise costs measured at factor prices to the market price level, using the standard conversion factor (i.e. the ration between the gross domestic product and gross factor income) (see Møller et al., 2000). For the period in question the standard conversion factor is equal to1.17. For internationally traded goods the conversion factor equals 1.25.

2.4.4 Delineation of society

A national delineation of society is applied implying that subsidies from the EU are regarded as income flows comparable to export revenues. As such, they are incorporated in the cost-benefit analysis after adjustment using the standard conversion factor. At this point, the present cost-benefit analysis deviates from the analysis conducted by COWI, where EU-subsidies were treated as transfer payments – and consequently omitted.

3. COSTS

The extensive construction activities and the loss of rent from agricultural land account for the greater part of the project costs. Total construction costs are calculated as the expenses already incurred as well as the budgeted expenditures for the remaining project period. As for the loss of land rent, the calculations incorporate an estimate of marginalization due to soil settling in the absence of the project.

3.1 Construction costs, etc.

The restoration of the Skjern River involves considerable expenses for projecting, construction, surveillance and information, cf. table below.

Table 2: Construction costs in *current* prices, DKK

Year	Projecting	Information	Surveillance	Miscell.	Construction	EU-subsidies	Total
1991	36,134			-31,440			4,694
1992	31,250			29,370			60,620
1993				8,836			8,836
1994	93,096	44,000	397,500	54,009		-6,772,370	-6,183,765
1995	50,216	107,925	917,915	15,407			1,091,463
1996	4,165,932	281,235	62,382	38,477			4,548,026
1997	5,461,574	87,480	58,536	43,258			5,650,848
1998	3,837,998	86,546	183,544	552,865			4,660,953
1999	3,816,807	745,224	96,816	1,690,937	25,760,080	-6,707,575	25,402,289
2000	1,521,394	864,113	2,808,158	1,412,837	41,550,542		48,157,044
2001	442,000	2,812,000	1,099,000	1,700,000	36,022,000	-6,047,500	36,027,500
2002	341,000	7,618,000	1,614,000	2,191,000	17,571,000		29,335,000
2003		5,122,000	1,919,000	424,000	50,000	-8,125,000	-610,000
2004		500,000	380,000	200,000			1,080,000
2005						-4,125,000	-4,125,000
Total	19,797,401	18,268,523	9,536,851	8,329,556	120,953,622	-31,777,445	145,108,508

In order to make the figures comparable expenses incurred before 2000 are inflated to the base year price level using the wholesale price index, and imputed interest (at 3% per annum) is added. Budgeted costs after 2000 are discounted at 3% per annum. Table 3 shows the cost components after these adjustments. Attributed to the year 2000 the sum of construction costs etc. amount to app. 140 million DKK.

Table 3. Construction costs attributed to the year 2000, DKK

Year	Projecting	Information	Surveillance	Miscell.	Construction	EU-project subsidies	Present value
1991	49,677			-43,224			6,453
1992	42,173			39,636			81,808
1993				11,647			11,647
1994	117,713	55,635	502,611	68,291		-8,563,195	-7,818,944
1995	59,910	128,759	1,095,109	18,381			1,302,158
1996	4,774,372	322,310	71,493	44,097			5,212,271
1997	5,962,384	95,502	63,904	47,225			6,169,014
1998	4,091,029	92,252	195,645	589,314			4,968,240
1999	3,931,311	767,581	99,720	1,741,665	26,532,882	-6,908,802	26,164,358
2000	1,521,394	864,113	2,808,158	1,412,837	41,550,542		48,157,044
2001	429,126	2,730,097	1,066,990	1,650,485	34,972,816	-5,871,359	34,978,155
2002	321,425	7,180,696	1,521,350	2,065,228	16,562,353		27,651,051
2003		4,687,356	1,756,157	388,020	45,757	-7,435,526	-558,236
2004		444,244	337,625	177,697			959,566
2005						-3,558,261	-3,558,261
Total	21,300,515	17,368,542	9,518,762	8,211,299	119,664,350	-32,337,143	143,726,325

3.2 Closure of fish farm

In connection with the project Kolbøl fish farm was closed in 1999. The closure involves an economic cost in terms of lost net returns ("resource rent"). No data was available for calculating the net return for this enterprise. Instead, the social cost were estimated as the market value of the maximum permitted amounts of feed. According to COWI (1998) the value of feeding permits were app. 12 DKK per kg (after inflation to year 2000 prices). The stipulated market value of the fish farm's (150 tons) feeding permits amount to app. 2 million DKK – after adjustment by the standard conversion factor.

3.3 Social costs of land re-allocations

In addition to construction and operating costs the government has made land purchases. Government purchases of land imply that ownership is transferred from private proprietors to the state. The expenses incurred through these transactions are not costs in economic terms, since the change in ownership does not entail a use of resources. The subsequent change in land use, however, represents a resource cost in the form of lost land rent. The calculation of forgone land rent is detailed in the following.

3.3.1 Marginalization assumptions

The purpose of the land reclamation project in 1962-68 was lowering the high water table to app. 1 meter below ground, which was achieved by digging draining ditches and establishing pumping stations. Organic soils were oxidized through drainage and cultivation and since then the ground has settled due to compression and decomposition of organic materials. This process gradually diminishes the distance between the surface the groundwater table. It is necessary, therefore, to investigate the effect soil settling would have had on land rent in the absence of the Skjern River project. Continued farming would have led to marginalization of a growing part of the arable land in the project area. The sooner marginalization would have occurred, the lower the social (opportunity) costs associated with using the land for the purposes in the project.

Drained land is considered marginalized, when soil conditions no longer permit arable cultivation. Alternative land use would be extensive grazing which yields a very modest land rent – at best. An area can be considered marginalized, when soil settling has reduced the distance between the surface and the groundwater table to such an extent that timely sowing and harvesting becomes uncertain - because the land is too wet to carry machines.

App. 1,750 ha of the 2,200 ha, that constitute the project area, were arable land until the restoration of the River. As shown in appendix I, the calculations demonstrate that app. 500 ha of this area could be considered marginalized prior to the implementation of the project, whereas app. 400 ha would have become marginalized during the following two decades. For app. 100 ha the remaining cultivation time has been estimated to 40 years. The remaining 700 ha could have been cultivated for many years to come.

3.3.2 Land rent calculations

The land rent from arable land is calculated for the following four types of soil in the project area: loam, humus, sand and sandy loam. The land rent estimates for the various soil types are from Schou et al. (2001). They are based on regional land rent data in SJFI's (Danish Institute of Agricultural and Fisheries Economics, 2000) accountancy statistics for agricultural enterprises. The present analysis assumes that the regional land rents recorded in Schou et al. are approximately equal to the rent obtained on the predominant soil type in individual regions. Hence, land rent from loam and humus in the project area is assumed to equal the average land rent recorded for the Eastern Islands (Wiborg, 2001). Land rent from the sandy soils is assumed to equal the average land rent in South and West Jutland. Sandy loam is supposed to provide a land rent equal to the average of the rent levels in the two above-mentioned areas.

When land has become marginalized land rent is usually assumed to be zero. But this is not necessarily the case under the present acreage payment scheme of the EU, which involves an obligation to set land aside. One must expect the rational farmer will allocate his set aside obligations to more or less marginalized land in the project area. As long as marginalized (or partly marginalized) land qualifies for acreage payments, it is rent bearing. The project means that (arable) land outside the project area must be set aside alternatively. In the present analysis the rental value of set aside land in the project area is calculated as the opportunity cost of setting aside (more valuable) land outside of the project area. In this context it is assumed that on the farms affected land is allocated (between the low lying areas in the River valley and dry land) in such a way that it would have been possible to fully utilize the marginalized areas (in the River valley) to fulfil set aside obligations. The quality of land surrounding the project area is assumed to be equal to the average for South and West Jutland. Thus, the opportunity cost of using marginalized land for project purposes is estimated as the average land rent in South and West Jutland.

The calculated land rent for arable land and marginalized land respectively is shown in table 4. As can be seen, rent within the project area varies from 1,450 DKK/ha/year for sandy loam (as well as marginalized/set aside land) to 2,850 year/ha/year for loam and humus.

Table 4. Rental value of agricultural land in the project area

Soil type	
Humus and loam	2,580 DKK/ha
Sand	1,450 DKK/ha
Sandy loam	2,015 DKK/ha
Marginalized land	1,450 DKK/ha

Kilde: Schou et al. (2001) together with own calculations.

3.3.3 Land rent from extensive grazing

Implementation of the project implies that 1,550 ha are expected to be used for extensive grazing (without fertilization or use of pesticides). The stock of dairy cattle in the region is assumed large enough to create the necessary supply of young stock (heifers) to graze these areas. The estimate of land rent from grazing is based on similar land use in Tipperne and Skallingen (coastal grazing areas), where dairy farmers pay for having their heifers at pasture – with fencing and surveillance provided by the Danish Forest and Nature Agency. The expected land rent from extensive grazing in the project area is calculated on the basis of information on revenue and expenses from the pasture activities in the above areas (Jensen, 2001). The calculated cost of fencing is based on Rude & Dubgaard (1987). Land rent from grazing in the project area is estimated to app. 170 DKK/ha/year. This means, that grazing – depending on the quality – will covers 5-10% of the land rent forgone by giving up arable farming.

3.3.4 Land rent forgone

The total economic costs associated with land use are calculated as the present value of land rent forgone by transferring arable land to pasture and nature areas. The present value of land rent in the absence of the project consists of two components: (1) the discounted land rent from the given soil type in arable use until marginalization due to settling (2) the discounted value of land rent from subsidised set-aside over an indefinite time horizon. The net costs due to the change in land use are calculated as the present value of land rent forgone, minus the present value of land rent from extensive grazing after completion of the project.

Table 5 shows the calculated net costs due to the change in land use. As can be seen land accounts for a social cost of app. 100 million DKK, when annual rent is discounted at a 3% rate over an indefinite time horizon. Using a discount rate of 7% would reduce the net present value to app. 46 million DKK. This is equal to an average reduction in land values of 58,000 DKK/ha at 3% and 26,000 DKK/ha at 7% (for the 1,750 ha of arable land affected by the project). If the time horizon of the cost-benefit analysis is reduced to 20 years, the project costs associated with land use drop to app. 45 million DKK at a 3% discount rate and 32 million DKK at 7%.

Table 5. Land rent forgone due to changes in land use

Discount rate	20 year time horizon	Indefinite time horizon
3%	44.8 mio. DKK	101.4 mio. DKK
5%	36.4 mio. DKK	63.0 mio. DKK
7%	32.3 mio. DKK	46.1 mio. DKK

As can be seen, the estimated economic costs associated with the change in land use depends to a great extent on the choice of discount rate, as well as the time horizon. No consensus exits as to what the appropriate level of the social discount rate should be. For environmental projects yielding benefits over a long period of time, it seems that analysts as well as (environmental) Government agencies prefer discount rates at the lower end of the above interval (see appendix II.5.3). This speaks in favour of land value estimates in the higher end of the above intervals.

What the choice of time horizon is concerned, farmland is usually considered an everlasting production factor. For the project area, however, this is a reasonable assumption only for about half of the farmland in question (because of marginalization due to settling). As noted, use of an indefinite time horizon rests on the assumption that it would be possible to obtain subsidies by entering marginalized land into the EU set aside scheme. It seems unlikely, however, that marginalized areas could have been included in the set-aside scheme for a lengthy period of time. Therefore, it must be concluded that choosing an indefinite time horizon will tend to overestimate the economic costs of the change in land use connected with the Skjern River project.

3.4 Effects on other sectors from change in land use

Land rent forgone is calculated under the assumption that termination of arable farming in the project area will not affect livestock production in the region. Two conditions must be fulfilled for livestock production to remain unaffected. First, it must be possible for livestock farms to meet the land-livestock balance requirements (legislation demanding an adequate amount of arable land for the disposal of animal manure). Second, the cattle farms must be able to maintain the necessary production of roughage. It is unlikely that the project will significantly affect roughage production, since fodder crops did not occupy large areas of arable land in the project area. According to the Ministry of Agriculture (1997) there is an ample supply of land not used for manure in Skjern and Egvad municipalities. Thus, the manure balance requirements are not expected to necessitate reductions of the animal production, but there may be a need for an increase in the transfer of animal manure between farms. It is possible that a future expansion of livestock production will imply that the amount of arable land will eventually become a limiting factor. Still, an increase in the economic activities associated with livestock production cannot be considered a social benefit as such. This is due to the fact that there is hardly any surplus labour in the Skjern area (see Dubgaard et al., 2001). Thus, from a welfare economic point of view the land restriction on animal production represents a social cost, only if a *rent* (i.e. pure profit) can be obtained through the expansion of livestock production.

It would have been interesting, nevertheless, to assess the effects on employment etc. of the Skjern River and similar nature restoration projects. However, an estimate of these effects would require analyses beyond the scope and financial resources of the present study. A complete assessment should include more than the negative employment effects on farming etc. The expected increase in tourism will create more activities and jobs in the tourism business. A priori, there is no reason to assume that the net effect of the project on local employment will be negative.

4. BENEFITS

A great deal of the investigations have been focused on the valuation of improved possibilities for outdoor recreation, hunting and angling together with the existence value of enhanced biodiversity. The value estimates of the remaining benefit components are based on the calculations by COWI in connection with the previous cost–benefit analysis of the Skjern River project (see COWI, 1998).

4.1 Savings on pumping expenses

Conversion of the arable land in the project area means that pumping is no longer required. The pumping cost saved is considered a benefit. Savings amount to 300,000 DKK annually from 1999, according to calculations made by COWI (1998). Pumping expenses in factor prices are transformed to market prices using the standard conversion factor. The annual saving amounts to app. 356,000 DKK. The present value for an indefinite time horizon is app. 12 million DKK at a 3% discount rate.

4.2 Improved land allocation

The Government has purchased app. 400 ha of farmland outside the project area in connection with the project. Where possible this land has been exchanged for land in the project area. At the same time land has been reallocated between farms in the area. The farms, to which the land in the project area belonged, are located outside the River valley (a few farms located were more than 10 km from their land in the project area). The re-distribution of land in connection with the project has shortened the overall distance to the fields. The land exchange and redistribution schemes affected app. 1000 ha. For the users of this land the distance to the fields has been reduced by 3 km on average, according to COWI's assessment.

COWI estimates the saved transportation cost to 225 DKK/ km/year. The savings have been achieved gradually during the period in which the re-distribution has taken place. COWI assumes that 25% of the savings occurred in 1992, 50% in 1994 and the rest in 1999. Fully implemented the savings associated with the programme are calculated to 860,000 DKK (year 2000 prices). The present value amounts to app. 30 million DKK for an indefinite time horizon at a 3% discount rate.

4.3 Termination of organic pollution from fish farm

The closure of Kolbøl fish farm results in environmental benefits through the termination of organic substance emissions. Within the project area the benefits of reduced pollution are included in the environmental benefits from improved fishing and recreational opportunities. However, there is a benefit in the form of reduced emissions of organic substances into Ringkøbing Fjord. In fact, the total emission of organic material was expected to end in Ringkøbing Fjord in the absence of the project.

The terminated of organic substance emissions is evaluated using the purification cost method. COWI (1998) estimates that a similar reduction could be realized by establishing a water treatment plant at a cost of 1,3 million DKK. Annual running costs would be 100,000 DKK. The depreciation period of the plant is estimated to be 20 years. At a 3% discount rate over an indefinite time horizon, the present value of running and capital costs of (alternative) water treatment amount to app. 6 million DKK.

4.4 Reed production

According to the project proposal, 300-400 ha of reed is expected to develop in the project area. COWI estimates that it will be possible to harvest app. 250 ha annually from the year 2005. COWI has estimated that the net return from reed production will amount to 1,400 DKK/ha (inflated to year 2000 prices and adjusted with the standard conversion factor) – or 350,000 DKK annually. According to COWI's calculations this is a net income (land rent) where all running costs have been deducted from the revenue. At a 3% discount rate over an indefinite time horizon, the value of reed production is app. 10 million DKK.

4.5 Flood risk

The restoration of Skjern River is expected to reduce the risk of floods outside the project area. App. 30 houses are affected (positively) by this. COWI estimates that the annual benefit will be app. 30,000 DKK - based on estimates of reduced flood risk and information from the National Floods Council on compensation expenses. This amounts to a present value of app. 1 million DKK at a 3% discount rate over an indefinite time horizon.

4.6 Nutrients and ochre

Transforming intensively cultivated land into a lake and meadows etc. will lead to a considerable reduction of the emissions of nitrogen, phosphorus and ochre. The reduction is due to reduced leaching from the converted arable area, as well as retention of nutrients in the River water when passing through flooded areas. The reduction of the nutrient and ochre load is calculated for the final recipient, Ringkøbing Fjord (the effect of the reduced ochre and nutrient load on Skjern River is incorporated in the environmental benefits evaluated for the project area as such). The social benefits of ochre and nutrient reductions are calculated using the purification cost method. The value of the reduction is measured as the (saved) costs of purification activities of the same magnitude elsewhere.

4.6.1 Nitrogen

The original project proposal and the environmental impact assessment of the Skjern River project expected an annual reduction of nitrogen pollution by 330 tons. A subsequent revision of the project means that the Skjern River will flow through the Hestholm Lake only periodically. As a result of this revision the original estimate regarding nitrogen reduction has been lowered. According to the Ministry of the Environment and Energy (2001a) the estimated removal of nitrogen by permanent wetlands is reduced by 1/3 to app. 180 tons N annually. After this modification the Skjern River project is expected to reduce nitrogen pollution by a total of 211 tons annually.

As already mentioned, nitrogen reduction is priced using the opportunity cost method. The cost estimates originate from investigations by the Danish Institute of Agricultural and Fisheries Economics (2000). The institute has calculated that establishing wet meadows is one of the cheapest alternatives for society, when it comes to limiting emissions of nitrogen into the marine environment. According to the investigation land rent will be reduced by app. 1,500 DKK per ha when arable land is converted to wet meadows (the amount is adjusted by the standard conversion factor). It is estimated that earth works etc. will cost app. 10,000 DKK per ha. The establishment of wetlands is assumed to reduce nitrogen loss by app. 350 kg N per ha annually. The unit cost price of nitrogen reduction through the establishment of wet meadows amounts to app. 5 DKK per kg N. Transferred to the Skjern River project the total value of nitrogen reduction equals 1.1 million DKK annually. The present value is app. 35 million DKK, at a discount rate of 3% over an indefinite time horizon.

4.6.2 Phosphorus

The annual retention and reduction of phosphorus in the project area is expected to be 14.5 tons, equal to app. 6 kg P/ha (the Danish Forest and Nature Agency, 1998). COWI has evaluated the reduction of phosphorus at the average costs of removing phosphorus at water treatment plants. This amounts to 80 DKK per kg. Priced at this level, phosphorus reduction in the project area represents a value of app. 1,3 million DKK per year (after correction with the standard conversion factor). This amounts to a present value of app. 44 million DKK, when using a 3% discount rate over an indefinite time horizon.

4.6.3 Ochre

Drained pyritiferous soil strata are leaking ferrous substances, which are converted into ochre and precipitates into streams and fjords etc. According to the environmental impact assessment (Danish Forest and Nature Agency, 1998) ochre pollution was a serious environmental problem in Skjern River Valley from the time the area was drained. The ENVIRONMENTAL IMPACT assessment estimates an annual reduction of ochre emission amounting to 635 tons. COWI (1998) has determined the purification costs using an ochre treatment plant. The treatment alternative would cost 1.97 DKK per kg ochre (when costs are adjusted by the standard conversion factor). This amounts to app. 1.3 million DKK annually for the expected reduction – or a present value of 44 million DKK at a 3% discount rate over an indefinite time horizon.

4.7 Groundwater

The County Council of Ringkøbing has designated areas of particular drinking water interests, areas of drinking water interests and areas of limited drinking water interests (Ringkøbing County, 2001). According to this mapping the project area does not represent any particular drinking water interests. Accordingly, groundwater protection is not considered an economic benefit in the present cost-benefit analysis

4.8 Climatic effects

The increased water level in the project area is expected to affect the emission of several greenhouse gasses – the amount of CO_2 (carbon dioxide) and N_4O (laughing gas) will be reduced, whereas the amount of CH_4 (methane) will increase. COWI (1998) estimates an annual CO_2– reduction by app. 15,000 tons. It is estimated that the effect of reduced laughing gas emissions is counterbalanced by the increased emissions of methane.

Reduced emission of greenhouse gasses is a global environmental benefit. The CO_2-effect of the project can only be considered a national benefit, if the reduction can be included in Denmark's international obligations to cutback on greenhouse gas emissions. Under the present conventions it is not possible to enter reductions of this kind in a country's CO_2-account. Since the Skjern River project does not contribute to satisfying Denmark's reduction obligations, the CO_2-effect is not included in the present cost-benefit analysis.

Recently concluded negotiations concerning the Kyoto protocol have created the possibility of deducting CO_2–absorption in so-called drains, i.e. forests and other forms of vegetation, in national CO_2–accounts. Because the interpretation is still uncertain this possibility is not considered here. If it turns out that the effect of the Skjern River project can enter into the national CO_2-account, it would be relevant to valuate this contribution using the opportunity cost method. The value of 1 ton CO_2–absorption could be determined from the costs of alternatively reducing CO_2–emissions through an expansion of the windmill capacity (offshore in order to avoid externalities in the form of landscape disamenities and other inconveniences connected with land-based windmills).

4.9 Hunting

Based on proposals from a user group the Ministry of the Environment and Energy has issued an instruction regarding public access and use of the project area (Ministry of the Environment and Energy, 2001b). According to this regulation, hunting is prohibited in the western parts of the area.

The Forest and Nature Agency states that there will be about 1,000 ha of hunting free areas, implying that hunting will be permitted on app. 1,100 ha (public as well as privately owned areas). An increase in the populations of migrating and resting birds is expected (see Madsen et al., 1995 and Laursen et al., 1997). According to Larsen (2001) large migrations of ducks have already been observed. The hunting value of areas, where hunting is allowed, is therefore expected to increase considerably subsequent to the completion of the project.

The cost-benefit analysis focuses on the *increase* in total hunting value as a result of the project. Theoretically, the increase should be calculated using welfare measures, i.e. as the sum of higher *hunting rents* (producer surplus) and the increase in *consumer surplus* accruing to hunters (see appendix II.4). To our knowledge, no valuation studies exist, which enable us to estimate a demand function for access to hunting in this area – or areas with similar characteristics. Thus, it is not possible to obtain an estimate the increase in consumer surplus. But the increase in the rental value of hunting (i.e. producer surplus) has been approximated.

The Danish Forest and Nature Agency expects an increase in the hunting value from app. 200 to app. 400 DKK/ha/year for state owned areas. On the privately owned areas, the hunting value is expected to rise from 200 to 600 year/ha/year. The difference is attributed to fact that on state owned land, hunting access will be given to local hunting clubs only. In addition a number of restrictions will apply. Private land owners, on the other side, will be able to rent out their hunting rights without such limitations. To compare, when a nature preserve was established in the (nearby) Nissum Fjord area, compensation for a ban on hunting on meadowland amounted to 500 DKK/ha/year (KOFE, 1998).

As mentioned, the implementation of the Skjern River project reduces the available hunting area by 1,045 ha. The hunting value lost by this would, at first, seem to constitute a project cost. However, the ban on hunting (in combinations with the restrictions on hunting in the remaining state owned areas) is expected to lead to an overall increase in game density. This in turn is expected to raise the value of hunting on privately owned land adjacent to the project area. For example, it is a well-known phenomenon that in the nearby area, Værnengene, the most attractive shooting stands are along the border of the hunting free area in the preserve, Tipperne. The value of the derived hunting improvement on adjacent land is estimated to be 400 DKK/ha/year of hunting free area – equal to an annual net hunting benefit of app. 200 DKK/ha. In the table below, the annual benefits connected with hunting are computed for the entire project area.

Table 6. Value of better hunting

	Area	Increase in hunting value DKK/ha/year	Total increase DKK per year
Privately owned areas	240	400	96,000
State owned hunting areas	840	200	168,000
Border effects	1,045	200	209,000
Total	2,125	-	473,000

The hunting improvement represents an annual economic benefit of app. 500,000 DKK – equivalent to a present value of app. 15 million DKK at a 3% discount rate over an indefinite time horizon. As mentioned, this is an estimate of the increase in producer surplus only. It was not possible to estimate the potential consumer surplus. In principle, the calculated increase in hunting value must therefore be considered as a lower bound approximation from a welfare economic point of view.

4.10 Angling

The following project features are of particular relevance to angling:

- Restoration of the lower 20 km of the Skjern River
- Establishment of a 160 ha lake
- Creation of a 220 ha delta.

Altogether, these changes are expected to improve angling opportunities considerably – not only along the restored part of the River, but also in the remaining parts of the River system. Of particular importance are the expected improvements in fishing for salmon and sea trout. Furthermore, it is likely that the aesthetic values, created by the restoration, will have a separate value for many anglers.

No valuation study has been made of anglers' willingness to pay for the improvements created by the project. The valuation of improved angling opportunities is based, therefore, on a transfer of benefit-estimates. The only research (known to the authors of this report) on willingness to pay for access to angling in Denmark, is part of a project conducted for the Nordic Council by Toivonen et al. (2000). This investigation uses various formats of the contingent valuation method.

It was estimated that Danish anglers' consumer surplus average 616 DKK/angler/year (measured as the hypothetical willingness to pay for access to angling minus the expenses connected with angling). In connection with the Skjern River project, the relevant benefit is the value of the expected improvement of the angling opportunities, in particular with regard to salmon and sea trout. The closest one gets to an estimate of willingness to pay for such a change in Toivonen et al., is based on the following question:

> ”Imagine that there were a River near your home which for many years had been closed for recreational fishing… The River has a natural stock of salmon and sea trout, which allows for an above average chance of catching these fish species. Imagine that the River is opened to recreational fishing with rod and line… To get access you will have to pay a rent that would grant you 12-month right to fish in the River… What is the most you would be willing to pay….?”

In Denmark the estimated willingness to pay for the above-mentioned scenario is in the interval 550–921 DKK/year per angler. The improvement of angling opportunities in the Skjern River, however, is not quite equivalent to the scenario in the above willingness to pay question. The most important difference is that there was also a possibility of catching salmon and sea trout in the Skjern River before the project. Basically, the estimated willingness to pay in Toivonen et al. must therefore be considered an overestimate in relation to the Skjern River project.

It is likely that a larger number of anglers will use the area subsequent to the completion of the project. COWI (1998) estimates that the restoration project will bring twice as many anglers to the area. We decided to disregard the increase in the number of anglers, because the estimate is extremely uncertain. On the other hand, we have chosen to use the willingness to pay estimate by Toivonen et al. for a *new* salmon water as a proxy for the value of the *improvement* of angling opportunities. As mentioned, this is probably an overestimate of the actual willingness to pay. It is not possible to determine whether the underestimate (due to the exclusion of extra anglers) is counterbalanced by the overestimate of willingness to pay. Thus, the resulting valuation must be considered a rough estimate.

Based on information from local anglers’ unions, COWI (1998) estimates that some 5,000 anglers are using the area. As mentioned, Toivonen et al. reached an estimate of willingness to pay for a new salmon water in the interval of 550–921 DKK annually per angler. If we assume that the 5,000 anglers will be willing to pay an extra 550–921 DKK per year, the value of angling will increase by 2.8–4.6 million DKK annually. At a discount rate of 3% over an indefinite time horizon the present values equal 93–153 million DKK. In the subsequent cost-benefit assessment, we use the smaller amount – to be on the safe side.

It should be noted that the stipulated consumer surplus is not a forecast of the extra rent accruing to the owners of angling rights in the Skjern River system. The extent to which the potential consumer surplus will be converted to rent payments depends on the circumstances – in particular whether the state is willing to offer fishing rights to local anglers on favourable terms. This is matter of distribution, however, which is not in itself relevant to the results of the cost-benefit analysis. From a welfare economics point of view it is the sum of the social benefits, that matter – not the distribution between consumers and producers respectively.

4.11 Outdoor recreation

Outdoor recreation is assumed to have played an insignificant role prior to the project – apart from angling and hunting. The size and character of the area allows for several types of outdoor activities. It is expected that the project will lead to a significant increase in the number of visitors, due to a large enhancement of the amenities and improved accessibility.

4.11.1 Willingness to pay for access

In Denmark there is free access to nature areas. Thus, outdoor recreation will not provide any return to the owners of the land in the project area. The social benefits consist of the consumer surplus obtained by the visitor’s in connection with their recreational activities. No valuation study has been undertaken to assess the recreational benefits from nature restoration in the area. For this reason consumer surplus is stipulated through transfer of willingness to pay estimates. As a point of departure is assumed that the Skjern River area will attain a status similar to that of other nature areas of national significance, e.g. the river Gudenåen and the landscape Mols Bjerge. Willingness to pay for access to Mols Bjerge was investigated in a previous study (see Dubgaard, 1996). A total of 3,300 visitors were interviewed about their use of this area. Their willingness to pay for access was elicited using the contingent valuation method. In the following, the Mols Bjerge study will be used as the basis for assessing the public’s (hypothetical) willingness to pay for access to the Skjern River area, once the project has been completed.

Mols Bjerge is situated in eastern Jutland app. 40 km north of Århus. With an area of 2,500 ha it is somewhat larger than the project area of 2,200 ha. The topography and flora and fauna of the two areas are considered to be of minor importance for the users’ willingness to pay for access. What is essential, is the fact that the Skjern River valley as well as the Mols Bjerge are unique natural areas – in a Danish context. Mols Bjerge, however, is situated closer to large urban areas than the Skjern River area. Thus, the average travelling distance to the Skjern River area will be longer than the distance to Mols Bjerge. This indicates that willingness to pay for access to the Skjern River area would be lower than willingness to pay for access to Mols Bjerge.

Average willingness to pay for access to Mols Bjerge is on the scale of 30–50 DKK per visit – depending on the question format (see Dubgaard, 1996). The interviews and, with them, the price level, are from the period of 1991-92. Inflated to the year 2000 willingness to pay amounts to 40–60 DKK per visit. In the following we will assume that average willingness to pay for access to the Skjern River area is 40 DKK per visit.

4.11.2 Number of visits

Due to differences in distance to densely populated areas, one can hardly expect the same number of visits in the two areas. Therefore, visitation counts from similar areas in western Jutland are also taken into consideration, when assessing the expected number of visits to the Skjern River area. The Tipper peninsula in the southern part of the Ringkøbing Fjord area has similar characteristics.
The Tipper peninsula consists of the privately owned area, Værnengene, in the south and the state owned area, Tipperne, in the north. Tipperne is a nature preserve where public access is permitted only on guided tours during a limited number of hours each week. During the past few years, the number of visitors has been in the range 7,000-10,000 annually (Christiansen, 2001). In Værnengene there is public access on roads and trails. There is a nature exhibition in this area, where a counter registers the number of visitors. According to Gregersen (2001), the registered number of visitors is between 30,000 and 40,000 annually (41,000 in the year 2000). However, not all visitors pay a visit to the nature exhibition. Gregersen estimates the total number of visits to Værnengene to be app. 60,000 annually. The number of visits to the Tipper Peninsula would probably be higher if there were free access.

The Skjern River Valley will presumably possess natural amenities and bird life equal to the Tipper Peninsula, but in addition a greater variation in outdoor recreation opportunities, due to the River and an larger number of recreational facilities. Visitation to the Tipper Peninsula must therefore be considered a lower bound approximation of the number of visits to the Skjern River area in the long term. The registered number of visits to Mols Bjerge was 160–170,000 annually (Dubgaard, 1996). Mols Bjerge is situated in a densely populated area. For this reason the number of visits here must be considered an upper bound approximation of the expected number of visits to the Skjern River area. An annual number of visits in the order of 90-100,000 seems a reasonable (cautious) estimate for the Skjern River Valley.

4.11.3 Recreational value

With an annual number of visits in the order of 90-100,000 and willingness to pay in the area of 40 DKK per visit, the expected recreational value of the Skjern River area will amount to app. 4 million DKK per year. At a discount rate of 3% over an indefinite time horizon, the present value amounts to 120 million DKK.

4.12 Existence value of increased biodiversity

As mentioned, the Skjern River project will improve the habitats for a number of rare and endangered species in Denmark. Despite the fact that relatively few species' survival depend on what we do in Denmark, most Danes undoubtedly consider the preservation of rare species in the country to be beneficial. This probably applies even when people do not expect to be able to observe the species in question – or make use of them otherwise. In this context we speak of *existence value* of biodiversity.

The existence value of enhanced biodiversity due to the Skjern River project is stipulated by transferring benefit estimates. The benefit estimates used are from a British valuation study of nature protection and restoration in the Pevensey Levels – an area similar to the Skjern River valley (see Willis et al., 1996). The Pevensey Levels study uses a variant of the contingent valuation method. The existence value of biodiversity is estimated as non-users' willingness to pay for the project.

4.12.1 The Skjern River area and the Pevensey Levels

To obtain realistic value assessments through the transfer of benefit-estimates from other projects, the following conditions must be fulfilled:

- In the baseline situation (i.e. prior to the implementation of the project) the characteristics of the areas must be similar, such as nature type and size of area
- The essential benefits of the project must be generically comparable
- The affected populations must be comparable with respect to socio-economic and other preference generating characteristics.

In the present case the two areas are reasonably comparable with respect to size (with a project area of 2,200 ha and Pevensey Levels of 3,500 ha). There will be adjusted for difference in size by transferring benefit estimates per ha. As for the essential benefits, the projects are comparable in the sense that the objective of both projects is to ensure/re-establish the biodiversity of wet meadowlands with nearly identical biological characteristics. The Skjern River project, however, is more comprehensive than the program in Pevensey Levels, because the latter area had not experienced drainage as thorough as the Skjern River valley. Hence, the estimates of willingness to pay for biodiversity improvements in Pevensey Levels must be considered a lower bound approximation relative to the Skjern River project, everything else being equal. The socio-economic and cultural differences between Denmark and Great Britain can probably be considered so modest, that they do not represent an obstacle to the transfer of benefit-estimates.

4.12.2 Transferring benefit-estimates

The greatest problem is differences of scale concerning the size of the populations of the two countries. To solved the scale problem the benefit-estimates are converted to unit benefits per household. Thus, the existence value estimate from the research area is divided by the number of households in Great Britain. Further, to adjust for the difference in area size willingness to pay per household is divided by the number of hectares in the research area. The value per household/ha is transferred to the Danish project area. Here total existence value is calculated by multiplying the transferred benefit estimate with the number of hectares in the project area and the number of households in Denmark.

Table 7. Benefit estimate of the existence value of biodiversity

	Pevensey Levels 3,500 ha	**Skjern River project** 2,200 ha
Number of households	21.7 mio. (UK)	2.4 mio. (Denmark)
Existence value/ha/year	£ 858	1,207 DKK
Existence value/household/year	£ 0.14	1.11 DKK
Total existence value per year	£ 3 mio.	**2.7 mio. DKK**

The process is illustrated in table 7. According to the calculations, the existence value of enhanced biodiversity in the Skjern River area amounts to 2.7 million DKK annually. At a 3% discount rate over an indefinite time horizon, the present value equals 86 million DKK.

Of course, there is considerable uncertainty attached to the above estimate of biodiversity existence value from the Skjern River project. To test the robustness of the estimate, two additional experiments will be made based on transfer of benefit-estimates of nature protection in the South Downs and Somerset Levels plus Moors (Willis et al., 1995). These areas are incorporated in the British Environmentally Sensitive Area Protection programme. They are larger than the Pevensey Levels. The South Downs is an area of app. 27,000 ha, whereas Somerset Levels plus Moors comprise more than 60,000 ha. Transferring estimates of biodiversity existence value from these areas provides us with the opportunity to test the sensitivity to scale with respect to area size.

Table 8. Benefit estimates transferred from South Downs and Somerset Levels

	The South Downs 27,170 ha	**Skjern River** 2,200 ha	**Somerset Levels plus Moors** 61,340 ha	**Skjern River** 2,200 ha
Number of households	16.4 mio. (Engl.)	2.4 mio. (Denm.)	16.4 mio. (Engl.)	2.4 mio. (Denm.)
Existence value/ha/year	£ 1,196	2,186 DKK	£ 656	1,198 DKK
Existence value/household/year	£ 1.98	2.00 DKK	£ 2.45	1.10 DKK
Total existence value per year	£ 32.5 mio.	4.8 mio. DKK	£ 40.2 mio.	2.6 mio. DKK

Table 8 shows the calculated existence values of the increased biodiversity of the Skjern River project, when benefit estimates are transferred from the above-mentioned studies. As can be seen, benefit transfer from the South Downs results in an existence value estimate for the Skjern River project of app. 5 million DKK annually, i.e. about twice the amount obtained when transferring benefits from Pevensey Levels. However, benefit transfer from Somerset Levels plus Moors gives nearly the same result as transfer from the Pevensey Levels study. Considering the range of these results the estimate of 2.7 million DKK (in table 7) seems cautious.

5. RESULTS OF THE COST-BENEFIT ANALYSIS

The calculated costs and benefits are assembled in table 9. The table displays a total of six “scenarios” for discount rates of 3%, 5% and 7%, each within time horizons of 20 years and infinity. Not surprisingly, the result is highly dependent on the choice of discount rate, as well as time horizon. A low discount rate and infinite time horizon each improve the result.

At a 3% discount rate and a time horizon of 20 years the present value of net benefits amounts to app. 30 million DKK. At 5% the present value of net benefits comes close to zero. At 7% the benefits can no longer cover the costs.

The project improves considerably when assuming an indefinite time horizon. Here, the Skjern River project turns out to be quite a good “bargain” for society at a discount rate of 3% - with the present value of net benefits amounting to 225 million DKK. At a 7% discount rate (the level recommended by the Ministry of Finance) the project provides a present value of 8 million DKK.

Table 9. Cost-benefit analysis of the Skjern River project

	Present values					
Time horizon	20 years, mio. DKK			Indefinite, mio. DKK		
Discount rate	3%	5%	7%	3%	5%	7%
Project costs	143.7	143.0	142.2	143.7	143.0	142.2
Operation and maintenance	12.9	13.3	14.0	17.0	14.9	14.7
Forgone land rent	44.8	36.4	32.3	101.4	63.0	46.1
Closing of fish farm	2.2	2.2	2.2	2.2	2.2	2.2
Total Costs	**203.6**	**194.9**	**190.7**	**264.3**	**223.1**	**205.2**
Termination of emission from fish farm	2.8	2.5	2.4	6.1	3.9	3.0
Saved pumping costs	6.0	5.1	4.5	12.1	7.4	5.4
Better land allocation	15.9	14.2	13.0	29.7	19.4	15.2
Reed production	4.6	3.6	2.9	10.1	5.0	3.0
Reduced flood risk	0.5	0.4	0.4	1.1	0.7	0.5
Reduction of nitrogen	20.3	17.0	14.5	35.8	23.7	18.5
Reduction of phosphorous	20.2	16.9	14.4	43.9	25.8	18.1
Reduction of ochre	18.6	17.7	16.9	40.5	27.0	21.3
Better hunting opportunities	7.0	5.9	5.0	15.3	9.0	6.3
Better angling opportunities	40.9	34.3	29.1	89.0	52.4	36.7
Outdoor recreation	55.2	46.3	39.3	120.1	70.7	49.6
Biodiversity, existence value	39.5	33.1	28.1	85.9	50.6	35.5
Total benefits	**231.5**	**197.0**	**170.5**	**489.6**	**295.6**	**213.1**
Welfare gain	**28**	**2**	**-20**	**225**	**73**	**8**

5.1 Conclusion

Naturally, valuation of non-market environmental benefits is associated with uncertainty. Add to this the uncertainty concerning the long-term development of price relations. Extrapolating the development in price relations is connected with great uncertainty – and this has not been attempted in the present analysis. Implicitly this presumes that price relations will remain unchanged over an indefinite time horizon - a restrictive condition of course. Finally, there is the question of how to determine the relevant social discount rate. Here, no professional or political agreement exists.

These uncertainties mean that the results of an environmental cost-benefit analysis should not be considered the final answer. Rather, one should regard economic valuation and cost-benefit analysis as experiments testing the robustness of a project to alternative assumptions regarding the magnitude of costs and benefits, and – not least - the various demands with respect to the return on invested capital.

The benefit estimates in the present cost-benefit analysis are drawn from the lower end of the value intervals found. With respect to costs, the stipulated set aside subsidies (in the absence of the project) must be considered as rather "optimistic" – and thus an overestimate of the land rent forgone. Combined, these assumptions imply that the calculated net benefits of the project must be considered a conservative estimate.

What the choice of time horizon is concerned, the results for the 20-year period must be considered very conservative estimates, since the flow of environmental benefits can be expected to continue in perpetuity. In the international economic literature arguments can be found for high as well as low discount rates. When it comes to long-term environmental effects, however, there is a tendency to prefer low discount rates, i.e. app. 3% (see appendix II.5.3). Discount rates in the interval 5%–7% must be considered as fairly high capital remuneration requirements for long-term investments.

The results of the cost-benefit analysis show that only when combining the two strong requirements – a 20-year time horizon with a 7% discount rate – the project fails the present value test. We must conclude, therefore, that from an economic point of view the Skjern River project is fairly robust. In other words, it seems that the resources, which have been allocated to the project, have been put to good use from a social point of view.

APPENDIX I: Assessment of land marginalization

Draining and cultivation cause the soil to settle in a way, which gradually reduces the distance between the surface and the groundwater table. An area is considered to be marginalized when the soil has settled to a degree, which makes the distance between terrain and groundwater critical, i.e. when timely sowing and harvesting is now longer possible because the land will be too wet to carry machines. The following is a documentation of the calculations regarding soil settling and marginalization in the project area (the Skjern River valley). The assessment covers the period from the completion of the land reclamation project in 1962-68 to the restoration of the River, as well as the (theoretical) development by continued drainage and cultivation in the absence of the project.

I.1 Modes of soil settling

Draining and cultivation cause a lowering of the ground level, partly due to mechanical compression, partly due to chemical withering.

Mechanical compression: Undrained peat soil contains a high percentage of water (90%). This amount is reduced considerably by drainage, which diminishes the volume of the pores. Mechanical compression is at its maximum immediately after draining. It is mechanical compression, which is assumed to be the primary contribution to total settling as a result of drainage (Pedersen, 1978).

Chemical withering: In undrained peat soil decomposition is a slow process due to oxygen and nutrient poor conditions combined with a sour environment. These conditions are changed drastically through drainage, fertilization and subsequent cultivation. This increases microbiological activity and thus the decomposition of organic substances on the soil (op.cit.).

It is assumed that drained land in the Skjern River area has been affected by both types of settling, to a very different extent though (The Danish Forest and Nature Agency, 1998). As both types of settling are caused by the lowering of the groundwater table and cultivation, it is assumed that settling would have continued in the absence of the project.

I.2 Settling rates

An estimate of settling rates for different soil types is required to model marginalization in the project area. The Danish Forest and Nature Agency (1998), Pedersen (1978) and Viborg County (1996) describe settling processes in Viborg County for soil types similar to those in the project area, i.e. sandy loam, loam and humus. We assume that these measurements are also representative of the settling processes in the project area. Table A.1 shows the calculated settling rates since the completion of the land reclamation project, together with the estimate future settling rates in the absence of the nature restoration project.

Table A.1. Settling rates in the project area

Settling before restoration	Settling rates in absence of restoration
0-45 cm	0.50 cm/years
45-90 cm	1.0 cm/years
90-150 cm	1.75 cm/years

I.3 Critical groundwater level

To calculate the time of marginalization for each area, it is necessary to determine the interrelationship between water table levels and yield variations. The water table level at which a given soil type become marginal due to cultivation difficulties, is termed the critical water table level. The critical water table level varies over the year. Thus, the water table must be lower during periods of sowing and harvesting (due to the demands on the ground's carrying capability) than during periods of growth.

According to soil maps from the Danish Hydrologic Institute (1996, 2000) the water table is highest during autumn. The following calculations are based on the water table level in spring, implying that a conservative estimate is obtained with regard to the influence of groundwater on marginalization. After discussing the matter with Peder K. Thomsen (2001) from the agricultural extension service, we have decided to employ the following guiding limits for critical water table levels in our marginalization calculations: loam 30 cm, humus 50 –70 cm and sand 50 cm.

I.4 Groundwater levels in project area

The closer the water table is to the surface initially, the sooner marginalization will occur – all things considered. The maps from the Danish Hydrologic Institute (2000) show that the water table varies greatly within the project area. In the eastern part the water table was 5–6 meters below terrain, while in the western part towards the mouth of the river there was open water periodically. The point of departure for the calculations was the water conditions during the spring (March) of 2000. Year 2000 was relatively dry. Accordingly, the estimates of water table levels prior to the restoration of the River are considered to be conservative.

The project area can be separated into two main parts; the area to the west and the area to the east of Skjern (town). The area west of the town covers app. 1,300 ha, the eastern area app. 900 ha. The groundwater table in the area west of Skjern was 0-1 meter during the month of March 2000. In the area closest to the mouth of the river there was open water in March, according to the Danish Hydrologic Institute (2000).

As a basis for settling and marginalization calculations, the western area is subdivided according to water table levels: West 1, West 2 and West 3. West 1 is the area west of the Skjern–Lønborg road and north of the southern Parallel Canal. West 2 is the area west of the Skjern-Lønborg road and south of the southern Parallel Canal. West 3 is the area east of the Skjern–Lønborg road and west of the town of Skjern. The groundwater level in the area east of Skjern was 1–5 m. The level drops rapidly after Ånum.

Based on the maps from the Danish Hydrologic Institute (2000), we have determined the average groundwater levels for each sub area to be as follows:

- West 1: 50 cm in March
- West 2: 0 cm in March
- West 3: 50 cm in March
- East: 150 cm in March.

I.5 Delineation of project area according to soil types

Of the 2.200 ha project area 1.750 ha (80%) were as arable land prior to the implementation of the project. The following marginalization calculations are for the cultivated area.

In order to calculate the land rent, the quality of the soil must be known. In the following, the soil type is used to indicate the quality (yield potential). The Environment and Energy Company and Geomasters (1987) have conducted a soil type registration of the project area using visual assessments to determine the composition of the soil. The resulting break down of the area (in percentage terms) according to soil types includes the whole project area – not the 1.750 ha of arable land specifically. In the following, we assume that the soil type distribution for the arable area is similar to that of the entire area. Furthermore, we assume that the arable share of the land is the same in each sub-area. On these assumptions, the arable area is distributed in sub-areas and soil types in table A.2.

Table A.2. Arable land in sub-areas according to soil type

West 1	**141 ha**	**West 2**	**257 ha**	**West 3**	**650 ha**	**East**	**696 ha**
Loam	108 ha	Loam	107 ha	Loam	376 ha	Loam	99 ha
Humus	13 ha	Humus	8 ha	Humus	212 ha	Humus	329 ha
Sandy loam	17 ha	Sandy loam	87 ha	Sandy loam	34 ha	Sandy loam	101 ha
Sand	3 ha	Sand	56 ha	Sand	28 ha	Sand	168 ha

I.6 Estimated extent of marginalization

The extent and the time of marginalization are calculated by integrating the area specific information on groundwater levels with the information on soil types/settling rates. Since we are dealing with model calculations, differences between estimation results and the actual extent of cultivation may occur. However, the modelling results are assumed to provide a reasonable picture of the overall level in the sense that a possible overestimate of the extent of marginalization in one sub-area will be balanced by an underestimate in another sub-area.

Table A.3 displays the results for the areas West 1 and West 2, where the process of marginalization is most advanced. Out of the 140 ha in West 1, 20 ha were marginalized before the implementation of the project, while the rest of the area would have become marginalized during the following 40 years, had cultivation continued. According to the calculations, all of the 257 ha in West 2 could be considered marginalized before the start of the project. This is not surprising, considering that the groundwater level is calculated to have been at the ground surface in March.

Table A.3. Marginalization in West 1 and West 2

West 1	**141 ha**	**Time to marginalization**	**West 2**	**257 ha**	**Time to marginalization**
Loam	108 ha	40 years	Loam	107 ha	Marginal
Humus	13 ha	Marginal	Humus	8 ha	Marginal
Sandy loam	17 ha	Marginal	Sandy loam	87 ha	Marginal
Sand	3 ha	20 years	Sand	56 ha	Marginal

In table A.4 it can be seen that marginalization was quite advanced in West 3 before the project started. According to the calculations, almost 250 of the 650 ha were already marginalized and the rest would have become marginalized over the following 20 years. In contrasts, marginalization of the app. 700 ha of arable land in area East would happen so far into the future that it does not affect the economic value of this land.

Table A.4. Marginalization in West 3 and East

West 3	650 ha	Time to marginalization	East	696 ha	Time to marginalization
Loam	376 ha	18 years	Loam	99 ha	240 years
Humus	212 ha	Marginal	Humus	329 ha	180 years
Sand	34 ha	Marginal	Sand	101 ha	200 years
Sandy loam	28 ha	9 years	Sandy loam	168 ha	220 years

To summarize, the calculations show that app. 30% of the arable area was marginalized before the start of the project. App. 25% would have become marginalized within the following two decades, while 40% could have been cultivated for many years to come.

I.7 Actual marginalization before restoration project

As mentioned, there may be differences between the model results above and the actual extent of cultivation in each sub-area before the project brought an end to arable farming. Informal assessments based on local knowledge form the following picture of the state of the area in the years prior to the restoration project.

West 1: App. 20 ha in the northeastern part of the area had been fallowed for several years and was strongly waterlogged. Add to this, small depressions and a waterlogged places in the western area towards the dike. Apparently, the model results, showing that 30 ha were marginalized, seem to be quite close to the actual conditions before the project.

West 2: The result of the model calculations (100% marginalization) overestimates the actual extent of marginalization. A certain part of the area was cultivated prior to the restoration work. Part of the land northwest of Lønborggaard is an elevated, sandy area with low cultivation risks. In the area north and east of Lønborggaard grain were grown in several places, but with increasing difficulty due a high water table. At the most it seems that 50% of the area was marginalized, while 30–40% would have become marginalized during the following 10-20 years.

West 3: Large areas had been fallowed for several years. Drier areas were cultivated, but in 1998 (wet late summer) harvesting could not be completed on part of that land. Several areas were grasslands, the output being used for grass cubes. Altogether, the model results appear to be realistic.

East: No marginalization according to the model calculations. But several smaller areas were apparently marginalized. In total probably 75-100 ha. Furthermore, several areas had visible problems, and would probably have become marginalized over the next 20–40 years.

Concluding assessment: The model calculations are likely to overestimate the extent of marginalization in West 2, probably by 100–150 ha. However, this overestimate is apparently balanced by an underestimate of the extent of marginalization and near-marginalization in area East. Thus, it seems reasonable to assume that the marginalization estimates in table A.3 and A.4 provide a realistic basis for calculating total land rent forgone. However, it is a somewhat problematic assumption that all marginalized land would have qualified for subsidies under the EU set aside scheme. It seems that some of these areas were water-logged/overgrown to such a degree that they could not have entered the set-aside scheme. However, for lack of resources to investigate land use by each proprietor, we maintain the assumption of full eligibility for subsidies.

APPENDIX II: Economic Theory and Methodology

II.1 Economic valuation and cost-benefit analysis

The increased focus on environmental issues during the last 3-4 decades has led to the development of economic valuation methods for non-market goods. The methods have been used especially for monetarizing the value of environmental benefits, in order to incorporate environmental considerations in social project evaluation (cost-benefit analyses) alongside with market goods. Welfare economic theory assumes that effective markets are able to allocate scarce resources according to consumer preferences. The objective of economic valuation of environmental benefits is to produce a basis for decision-making, which makes it possible to allocate society's resources in accordance with the individual preferences of the population.

Environmental decisions are usually based on physical or biological analyses, possibly supplied with estimates of the social costs, which various environmental measures and initiates will create. From a welfare economic point of view, this approach is considered a political short cut. Natural science is able to provide information on the effects of human activities on air, water, eco-systems etc. But such scientific results do not show how to weigh environmental benefits against other goods. Even though the costs of environmental policies are often included in decision-making, there is no economic measure of the environmental benefits created by the effort. Thus the components, which we compare, are incommensurable, i.e. physical or biological components on the one hand and economic components calculated in monetary units on the other. Therefore, one cannot determine whether society would have been better off allocating more or fewer resources to the environmental field.

The changes in environment, caused by pollution etc., are economically relevant because they affect the welfare of society. This happens indirectly through affecting the costs of production, and directly through changes in e.g. the population's health and the possibilities of aesthetic and cultural experiences. Economic valuation measures these welfare effects in monetary units. Subsequently it is possible to conduct a cost-benefit analysis, showing whether or not a project will increase social welfare. A project should only be accepted if the total amount of benefits is greater that the total costs.

II.2 The concept of benefits and value in welfare economics

The natural environment is a prerequisite for human existence, as we know it. The absolute value of nature is thus infinite. Therefore, it only makes sense to valuate marginal changes in the quality of nature and environment. What is to be considered as marginal changes depends on e.g. physical and biological assumptions about the tolerance thresholds of nature and ethically defined comprehensions of what human beings should or should not do in relation to nature. We will approach these questions further in the part concerning criticism of economic valuation.

In a welfare-economic sense value originates from individual preferences for various goods, market as well as non-market, in with willingness to substitute between these (see e.g. Freeman, 1993). The value of a unit of a given good is measured as the amount of another general good, which the individual is ready to relinquish in order to obtain an extra unit of the good in question. The general good used for measuring value is usually money. This is not due to the fact that money is of value in itself, but rather that money is a numeraire for the large variety of items in the bundle of consumer goods. Accordingly, the objective of economic valuation is not to attach a (market) price to all non-priced goods, but rather to reveal the social value of non-market goods.

II.3 Environmental value categories

The environment/nature provides a large number of physical, biological and aesthetic benefits, which directly or indirectly enters into production and consumption. Together with labour and produced capital goods, environmental benefits enter into the economic processes, which satisfy human needs. Environmental benefits can be categorized as use values, option values and non-use values.

Direct use value: The benefit people experience from direct use of environmental goods, either personally (e.g. recreational areas) or as a production factor (e.g. groundwater, fish stocks, etc.)

Indirect use value: Includes a wide variety of ecological qualities/ benefits. This concerns e.g. filtration and decomposition of polluting substances, as well as CO2-storage of forests.

Option value: Defined as the value individuals experience from knowing that they have the opportunity to use existing environmental benefits, e.g. recreational areas.

Non-use values: Values, which people ascribe to environmental benefits, without the direct use of them. The fact that people ascribe value to nature benefits, independent of their use, can partly be due to the satisfaction from merely knowing that they exist *(existence value)*, partly the wish to show consideration for the welfare of future generations *(bequest value)*.

II.4 Welfare measures

The value of a change in the amount or quality of a (non-market) good is calculated in welfare measures, i.e. producer surplus or consumer surplus.

II.4.1 Consumer surplus

The concept consumer surplus is based on the fact that, as consumers, we would often have been willing to pay a larger amount of money for the consumed amount of a specific good, than the amount we actually pay, rather than dispensing with the consumption in question. Consumer surplus equals the amount that we would be willing to pay as a maximum minus the amount that we actually pay (the various (Hicksian) varieties of the consumer surplus concept are described in Freeman, 1993). From a welfare economics point of view, value (in general) cannot be calculated as the price multiplied by the traded amount. Let us use a toll bridge as an example; here the users pay to pass, thus creating a certain amount of revenue. In a welfare economic sense, the revenue received by the bridge consortium will usually be smaller than the social value of the services of the bridge. This is due to the fact that the marginal utility of a great number of the crossings exceeds the fee. If a user pays e.g. 200 DKK to pass a bridge, but would not have refrained from passing until a fee of 250 DKK was charged, the transaction creates a consumer surplus of 50 DKK. A cost-benefit analysis calculates the value of the total benefits of the bridge as the toll plus the sum of each road user’s consumer surplus. This is the amount we must compare to the social costs of providing the good – not the payments.

When dealing with an afforestation project the idea is, theoretically speaking, the same. Benefits connected with outdoor recreation are solely calculated in consumer surplus, as the public does not pay for access. The purpose of valuation is thus “revealing” the amount, which each user would be willing to pay as a maximum for being able to use the new forest, rather than dispensing with the afforestation project. The total amount of benefits in connection with outdoor recreation in the forest is calculated as the aggregate amount of consumer surpluses.

II.4.2 Producer surplus/resource rent

The welfare measure of producer surplus corresponds to the concept of consumer surplus. In the present context, the most relevant measures of producer surplus are resource rent and land rent. Resource rent is the amount left, when total costs connected with using a resource is deducted from the revenue obtained (see e.g. Hartwick and Olewiler, 1998). The resource rent acquired by using land for farming, forestry etc. is usually referred to as land rent. Land rent constitutes the difference between the value of the crop and the total costs of cultivating the land – seed, fertilizer, and chemicals etc., as well as wages, depreciations and imputed interest on machines and equipment.

Usually, the employment created by the implementation of a project is seen as a benefit in itself. In welfare economics, however, neither increased employment, nor increased economic activity in general are considered benefits in themselves. The fundamental point is that such factors of production usually have alternatively uses. Only to the extent that a project reduces unemployment would it be appropriate to consider labour as free – from a social point of view.

II.5 Discounting.

Discounting (at a positive discount rate) means that a given consumption possibility will be weighed lower in the future than at present. The discount rate thus constitutes a trade-off relation between dispensing with present consumption in return for more consumption in the future.

II.5.1 The prescriptive approach

This approach is based on Frank Ramsey's groundbreaking article on optimal economic growth from 1928. Ramsey's theory builds on two neo-classical assumptions of a psychological and technological nature respectively. The first one is the utility theoretic assumption that increasing per capita income/consumption is accompanied by diminishing marginal utility. The second one is a technically founded assumption that an increase in the amount of capital goods in proportion to the amount of labour in the aggregated production function leads to a decrease capital's marginal product. Future consumption per capita can be augmented through net investment (dispensing with present consumption), but this becomes increasingly difficult due to decreasing productivity of capital. Add to this the difficulty of increasing social welfare through increased consumption due to the decrease in marginal utility, as people become increasingly wealthier. In other words, the accumulation of capital can be advanced so much that the loss of welfare at present (decreasing consumption is connected with increasing marginal utility) exceeds future gains due to the combination of decreasing capital productivity and marginal utility.

Chichilnisky has proposed an intergeneration welfare function, sensitive to the benefits of present as well as future generations – thus avoiding what Chichilnisky refers to as "dictatorship of the present" as well as "dictatorship of the future" (see Chichilnisky, 1997 for details). This could be realized by using a declining discount rate. Investigations of individual behaviour indicate that people discount in scenarios where they weigh social costs against future benefits – using a decreasing discount rate over long time horizons (ibid.). Thus, a discounting principle based on cautious expectations regarding future growth opportunities will apparently be in good agreement with individual time preferences.

II.5.2 The descriptive approach

Critics of the prescriptive or normative deduction of the social time preference rate claim that the discount rate should be determined on the basis of actual policy decision and the opportunity cost of capital determined by the market (see e.g. Nordhaus, 1994). Nordhaus argues that it would be inconsistent to use a discount rate in sustainability analyses, which is lower than what is found in other social contexts. Rather, the social returns from limiting e.g. the greenhouse effect should be equivalent to the returns to capital in the best alternative use. The basis for this claim is that environmental investments would otherwise crowd out investments with a higher return, which is not in agreement with a welfare maximizing allocation of resources. The interests of future generations should be considered through other forms of redistribution than long-term, low interest environmental investments. In the Danish debate, this way of reasoning has been supported by Bjørn Lomborg arguing that the current climate policy is irrational (Lomborg & Larsen, 1999). However, the premise that future generations should be compensated raises ethical questions. Neither national nor international redistribution mechanisms exist to ensure that future generations will actually be compensated for damages suffered.

II.5.3 Selecting a social discount rate

The magnitude of the discount rate is often essential to the outcome of a cost-benefit analysis. This is especially true for projects, where most the costs are incurred in the initial stages, while the flow of benefits are distributed over a long – possibly infinite – time horizon. These are the usual characteristics of nature restoration projects. Unfortunately, no agreement exists on which discount rate can be considered the most relevant in social cost-benefit analyses. A group of economic analysts from the Danish Environmental Research Institute and agencies under the Ministry of the Environment and Energy recommend a social discount rate of 3% in social cost-benefit analysis (see Møller et al., 2000, p. 140). This recommendation is based on an estimate of consumers’ time preference rate – measured as the real rate of interest (after tax) in the capital market during the nineties. However, the Ministry of Finance (1999) recommends a social discount rate in within the range of 6–7%. According to the estimates by the Ministry of Finance, this level can be inferred from consumers’ rate of time preference as well as the opportunity costs of capital (Ministry of Finance, 1999, p. 72). Accordingly, it is not differing theoretical approaches that lead to conflicting recommendations regarding the appropriate level of the social discount rate.

The USA has a similar discrepancy between the recommendations of the environmental and financial authorities. Concerning intra-generational discounting (i.e. short and medium –term), the recommendation of the U.S. Environmental Protection Agency is to use a social discount rate of 2-3% - based on consumers’ rate of time preference, estimated from the market interest rate after taxes (see U.S. EPA, 2000, p. 48). When dealing with inter-generational discounting (i.e. the very long term, where the welfare of future generations is involved), EPA recommends sensitivity analyses with discount rates at levels down to 0.5% (Ibid, p. 52). However, the American Office of Management and Budget recommends a standard discount rate of 7% for social cost-benefit analyses – based on the opportunity cost of capital (see U.S. OMB, 2000, p. 7). Still, the OMB agrees with EPA that using the consumers’ rate of time preference would result in a social discount rate of 3% (Ibid), but this is not the rate recommendable for social project assessment. Norway employs social discount rates of 3,5–8%, depending on the risk concerning the returns from the project (see Ministry of Finance, 1999). The recommended social discount rate in Great Britain is 6% (Ibid).

Considering the problems connected with determining the appropriate social discount rate, one might be tempted not to use discounting at all in environmental project analysis. But completely ignoring economic efficiency when considering resources allocation over time would result in serious analytic problems – in particular with nature restoration projects etc., where the flow of benefits is assumed to last indefinitely. At a discount rate of zero the accumulated value will approach infinity regardless of how small the annual benefits are, as long as they are positive. Thus, it makes no sense comparing the up front costs with the expected benefit stream without discounting. Fixing a (positive) social discount rate is necessary in order to conduct efficiency analyses of the type of projects, considered in this context. However, economic literature does not provide a basis for firm conclusions regarding the relevant level of the social discount rate. In the present report the starting point is the discount rate suggested by the "environmental side", which is 3% - complemented with calculations at discount rates of 5% and 7%.

II.6 Valuation methods

Economic valuation of environmental benefits has been practiced since the 1950s. USA is leading in this area; here, economic valuation is incorporated in environmental policy decision-making. A driving factor in the development of valuation methods has been increasing demands for economic efficiency analyses in American environmental legislation. In the following, we will investigate in more detail the methods used in economic valuation, including methods, which do not lead to valuation in the strict sense, but rather to pricing of non-market goods.

II.6.1 Valuation versus pricing

There are different theoretical approaches to monetarization of non-market goods; preference based and non-preference based, respectively. The methods based on preferences attempt to estimate behavioural relationships in the form of demand functions or marginal willingness to pay functions, i.e. the connection between the price level and the amount demanded. A relationship, which could be observed statistically, if the good were traded in a market. In other words, valuation methods attempt to disclose people's willingness to pay (e.g. through taxes) for goods with no market price. The estimated willingness to pay function reflects individuals´ rate of substitution between the non-market and the relevant bundle of market goods. The value of a given environmental undertaking is computed in terms of welfare measures, i.e. changes in consumer surplus due to changes in the quality or amount of the environmental benefit in question. Let us consider e.g. measures taken to limit the pollution of groundwater. To evaluate such a policy one must elicit the maximum amount of income (purchasing power) people are willing to give up in order to ensure that certain groundwater quality standards are observed.

The non-preference based methods can be described as pricing. Pricing methods are not based on the economic behaviour of individuals, but usually on the costs connected with realizing a given environmental objective. If we use the groundwater example again, a policy requiring a certain standard for the nitrate content in groundwater can be priced as the social costs incurred by realizing this standard. Cost relations are of course extremely relevant, when assessing an environmental policy. But pricing does not show whether people's willingness to pay "meets" the costs – nor if there is willingness to pay for an even greater effort. Thus, pricing does not answer the fundamental question of how scarce resources should be allocated between environmental objectives on the one hand and fulfilment of other human needs on the other.

II.6.2 Pricing methods

When monetarizing environmental benefits based on market prices, there are several approaches, e.g.:

- Opportunity cost method: Monetarizes the benefits of a non-market environmental resource based on the costs of ensuring similar benefits through alternative activities. For example, the "price" of pure groundwater for drinking water supplies can be calculated as the treatment costs of removing nitrate and various chemicals from groundwater. The method does not show whether or not consumers' preferences/willingness to pay for the purity of groundwater is larger or smaller than the costs of maintaining the current standard.

- Replacement costs: The price of an environmental benefit can be considered equal to the cost of producing a similar environmental benefit in other ways. If a pond is abolished in connection with construction work, the loss of this amenity can be priced as the costs of establishing a similar pond in a nearby-area. This method is limited to environmental resources that can be recreated with qualities, which are reasonably similar to those lost. Even when this is physically possible, it is not certain that the affected individuals are willing to pay an amount equal to the costs of replacement.

Pricing methods are usually easier to apply than the preference-based valuation methods, but, from a welfare economics point of view, pricing is not necessarily the correct way of measuring the social value of benefits connected with environmental policy initiatives.

II.6.3 Contingent valuation method

The Contingent Valuation Method (CVM) stipulates a scenario for the preservation or production of a non-market good, e.g. an environmental good. Having explained the characteristic of the good, the rules of provision, access, method of payment etc., respondents are asked to state their willingness to pay (e.g. through taxes) for the good in question. Various interviewing techniques and statistical methods have been developed to prevent strategic behaviour by respondents. Also, statistical methods are applied to test the consistency between stated willingness to pay and the assumptions of economic theory regarding rational economic behaviour.[1]

In addition to questions about willingness to pay, Contingent Valuation surveys also include a number of questions concerning the respondent's preferences for or use of the valuated good, together with demographic and socio-economic characteristics. De-briefing questions are often asked to clarify whether the respondent has understood the scenario in question. The collected demographic and socio-economic data are subsequently used for analyses of validity, typically using regression analysis to investigate economic behaviour.

II.7 Benefit transfer methods

Conducting economic valuation by state-of-the-art criteria is time-consuming – and costly. Hence, the interest in reusing the results of previous valuation studies – referred to as benefit transfer – is increasing. Benefit transfer is a transfer of valuation estimates or functions from a research area (i.e. an area, in which a valuation study has been conducted) to a project area (i.e. an area where one

[1] A detailed description of the various techniques in contingent valuation can be found in Mitchell & Carson (1989), together with Garrod & Willis (1999). Hanemann & Kanninen (1998) go through the statistical methods used for analysing (binary) CV response data.

wishes to evaluate a project before a possible implementation). There are three methods of benefit transfer: 1) Transfer of unit values; 2) Transfer of adjusted unit values and 3) Transfer of the entire valuation function from the original study (see e.g. Garrod & Willis, 1999). The simplest procedure is transfer of unit values, e.g. the estimated willingness to pay per ha of a re-established nature area. It will often be necessary to adjust the unit values, e.g. by considering differences in income between the research area and the project area. From a methodical point of view, the best procedure would be to transfer the entire estimated valuation function from the original study – with the various explanatory variables regarding socio-economic and geographic characteristics etc. However, data limitations often set narrow limits on the extent to which the original estimates can be calibrated.

Considering the limited possibilities of correcting the numbers, selecting the proper valuation studies becomes the essential criterion regarding the reliability of the transferred benefit estimates. Desvousges et al. (1992) identify five criteria for selecting valuation studies for the purpose of transferring benefit estimates:

- The employed valuation studies must fulfil state-of-the-art criteria for economic valuation
- The studies must thus contain regression results, describing the willingness to pay as a function of socio-economic characteristics etc.
- The research area and the project area must, to the greatest extent possible, contain coinciding characteristics regarding the natural setting as well as the pattern of utilization
- Consumers´ substitution possibilities between various environmental benefits in the research area must be similar to the substitution possibilities found in the project area.

Experiments with the methods of benefit transfer show that there is a considerable uncertainty connected with this sort of benefit evaluating (Garrod & Willis, 1999). Yet, benefit transfer is recommended as an acceptable procedure by e.g. American and British environmental agencies (see U.S. EPA, 2000 and U.K. Treasury, 2000). All things considered, it seems that one can get a fair impression of the orders of magnitude for various environmental benefits through benefit transfer. As far as possible, however, actual policy-analyses should be based on data collected through primary research.

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