Biodiversity in the Dutch practice of cost-benefit analysis

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Abstract

According to the Dutch cost-benefit guidelines, biodiversity points are an innovative and practical method to measure the impact of policy measures on biodiversity. A major use is to compare the cost-effectiveness of project alternatives with respect to their impact on biodiversity. For assessing the net benefits of projects, it is more informative than qualitative or ordinal expert opinions on a policy measure's impact on biodiversity. This paper provides the first overview of this method in Dutch CBA practice. The way nature has been incorporated in Dutch CBA has changed drastically over time: from CBAs in which major impacts on nature were not even mentioned to CBAs that value the impact on ecosystem services as much as possible and measure effects on biodiversity by biodiversity points. The calculation and use of biodiversity points are illustrated by five case studies on water management with nature as a trade-off or co-benefit. These examples show that the applicability of biodiversity points differs per type of nature. It is more difficult for water quality related biodiversity than for land biodiversity, as the impact area is larger and the impacts are more difficult to define. The usefulness of biodiversity points in CBA can be advanced by providing overviews of their costs per point at various locations and for various habitats. This provides insights into the cost-effectiveness of alternative compensation or protection measures. Also the willingness to pay for such points can be investigated and may then later incorporated in future CBAs.

Key-words: Cost-benefit analysis, ecology, biodiversity, nature, water management, infrastructure

JEL-codes: H43, H54, Q51, Q57

1 Introduction[1]

For many cost-benefit analyses (CBA), properly assessing the welfare effects of a policy measure on nature is important. This does not only apply to CBA's on nature policy, but also to those on other policy areas such as mobility, agriculture and water safety, as the policy measures in these policy areas often have negative impacts on nature. For example, a new road connecting two cities through a forest is good for mobility but bad for nature.

Various strands of literature have addressed the question of how to incorporate the effects of a policy measure on nature in CBAs. However, in scientific literature on CBA, CBA guidelines and textbooks and CBA practice, there is no general agreement on how to define and assess the welfare impacts due to changes in nature, landscape or environment (Boyd et al., 2014; Schaefer et al., 2015).

In the scientific literature, a large number of studies provide monetary values of the welfare effects of changes in nature (see e.g. TEEB, 2010; Markandya, 2016) or discuss methodologies that can be used in CBA (see e.g. Atkinson and Mourato, 2008; Freeman et al., 2014; Johnston et al., 2017). In this literature, there is a clear bias towards studies focusing on novel estimation methods without considering their practical applicability (Laurans et al., 2013). Effects on nature in these studies are described in general terms, without specifying the impact of the policy measure e.g. on the number of visitors to a park, the appreciation of an area, the health effects of replacing a forest by a road or effects on land productivity. As a consequence, they often yield unreliable estimates in monetary terms or estimates that cannot be used in a CBA for analyzing specific policy measures (Bartkowski et al., 2015).

General CBA guidelines[2], general CBA textbooks (e.g. Boardman et al, 2006, and Mishan and Quah, 2007) and even guidelines on CBA and the environment (e.g. OECD, 2006, 2018 and EPA, 2014) only pay limited attention to nature, and do not specify how changes in nature affect welfare and how they can be measured. The studies on the Economics of Ecosystems and Biodiversity (TEEB, 2010) have advanced the literature in this field, but they do not provide clear guidelines on which ecosystems to include, how to include biodiversity, how to deal with substitutability and how to prevent double counting. Due to this lack of clear guidelines, CBA practitioners employ varying definitions of what 'nature' is and how changes in nature affect welfare. This also causes problems in defining what to value.

The Netherlands have a long tradition in cost-benefit analysis (CBA).[3] The way nature has been incorporated in Dutch CBAs has changed drastically over time: from CBA's in which major impacts on nature were not even mentioned to CBAs in which the impact on ecosystem services are valued as much as possible and effects on biodiversity are measured by biodiversity points. These biodiversity points measure the impact of a policy measure on the amount and the quality of biodiversity in a standardized way. It takes into account the area of ecosystems affected, the ecological quality of each area and a weight factor per type of ecosystem reflecting the contribution of the ecosystem to species richness and the threat level to that ecosystem.

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[2] See e.g. World Bank (2010), the Asian Development Bank (2013), the USA Benefit-Cost Center (Zerbe et al, 2010), the UK Greenbook (HM Treasury, 2011) and the EU CBA guidelines for investment in infrastructure financed by the cohesion funds (European Commission, 2014).

[3] For more than a century, CBA is used to support decision-making on public investments in the Netherlands, see Bos and Zwaneveld (2017) and Bos (2008).

This paper contributes in three ways to the existing literature on CBA and nature. Firstly, international guidelines on CBA and nature (e.g. Pearce et al, 2006; EPA Guidelines, 2014) focus on discussing valuation issues, usually in rather general terms and with a strong focus on the analytical methodologies. This paper stresses that to support decision-making, it may be more informative to put an equally strong focus on defining which effects on (quality and quantity of) nature to include in CBA and how to ensure that only the effects relevant for welfare are included. Secondly, this paper provides an overview of methods applied in Dutch CBAs to measure the volume and quality of ecosystem services and biodiversity, with a focus on the biodiversity point method. The biodiversity point method was developed in the Netherlands in 2009 and measures the amount and quality of biodiversity and their changes in a standardized way. Thirdly, this paper describes and discusses the evolution in Dutch CBA practice towards the use of biodiversity points.

The outline of this paper is as follows. Section 2 starts with a general overview on CBA and nature in the Netherlands. In the subsequent sections, five case studies on water management and nature are discussed. The two case studies in 2000 and 2005 on more room for water compare various alternatives on their cost-effectiveness for nature. They are the topic of section 3. These first two case studies illustrate how the impact on nature was measured in cost-effectiveness analysis before the introduction of the biodiversity point method. The method of biodiversity points and its application in three different analyses are discussed in section 4. Conclusions about the merits and limitations of biodiversity points in cost-effectiveness analysis and a fully-fledged cost-benefit analysis are drawn in section 5.

2 General overview on CBA and nature in the Netherlands

Early CBAs on flood risk ignoring major negative effects on nature

Up to the 1970s, CBAs mainly pertained to major investments in flood risk management. Examples include the 30 km long Southern Sea enclosure dam and the Deltaworks, each of which costed about 6 to 7% of GDP. The impact on nature was usually not included in these CBA's.

The 1901 CBA on the Southern Sea enclosure dam (Lely, 1901) looked at many different types of costs and benefits, but ignored the negative impact on nature. Similarly, following the massive flooding of the southwestern part of the Netherlands in 1953, the CBA on the Deltaworks (Tinbergen, 1953) compared two alternatives to ensure sufficient flood risk safety: raising and strengthening dikes all along the waterways versus shortening the coastline by blocking the estuary mouths with barrier dams (Deltaworks). Many different types of costs and benefits were monetized, quantified or at least mentioned. But closing off the estuary mouths by barrier dams would turn tidal salt water areas into fresh water lakes like the IJsselmeer (the former Southern Sea); these substantial negative effects on nature were ignored in the CBA.

Environmental impact analysis (EIA) as an input for CBA

Reporting environmental effects of public investments, including those on nature, started in 1978. NEI and RIN (1978) presented an Environmental impact analysis (EIA) and a CBA comparing the extension of the port of Den Helder with alternative solutions in the ports of IJmuiden and Rotterdam. Basically, most effects on nature were given in physical terms that were presented next to monetary costs and benefits. Some effects on nature were monetized, in particular the foregone revenues of fishing, the loss of shell lime production and the loss of water cleaning capacity. The impact of a new port on five basic functions of nature (production function, intermediary and supporting function, informative function, regulatory function and conservation function) was specified and at least scored qualitatively (with minus and plus signs) for 13 different sub-functions. Nearly a decade later, a European Act[4] made environmental impact assessments (EIA) obligatory.

Unlike a CBA, EIA does not translate positive and negative effects in nature into monetary terms and usually do not consider double counting, i.e. whether several environmental impacts lead to the same impact on welfare. But their information can be used as an input for CBA. For example, in the CBA on deepening the Westerschelde-waterway from the Netherlands to Antwerp (Saitua, 2004), the EIA was used to claim that from a European perspective the environmental effects were negligible. This is still the role of EIA in most Dutch CBAs on transport infrastructure and spatial projects (see Annema and Koopmans, 2015).

National guidelines on CBA and nature

To improve the quality and consistency of CBA, national CBA guidelines for transport infrastructure were developed (Eijgenraam et al., 2000). It does not explicitly discuss the effects on nature of infrastructure projects. The valuation of effects on nature in CBA was separately addressed in a supplementary guidance (Ruijgrok et al., 2004) and an overview with key-figures for such valuation of nature (Witteveen & Bos, 2006).

As a result, attempts were made to include e.g. effects of changes in nature on housing prices, health and recreation. Due to shortage of data and a lack of primary valuation studies, this resulted in many cases in arbitrary assumptions or token entries – indicating that the effect was relevant but that no reliable monetary value could be estimated. In other CBAs, some impacts were double counted or other errors were made in quantifying and valuing the welfare effects in terms of cost and benefits.

In 2013, an updated CBA guideline was published by CPB and PBL (Romijn and Renes, 2013), which included a brief discussion of accounting for the impact on nature.[5] This topic is covered more in-depth in the supplementary guideline on CBA and nature (Klooster et al., 2018). The guideline on CBA and nature recommends the use of biodiversity points. It also stresses the importance of providing clarity about the welfare effects of changes in nature. For example, most regulating services, like natural pest control and water purification, are intermediate services. They indirectly affect welfare as they are an input in the production function for final ecosystem services. Effects on these intermediate services are to be indirectly included in a CBA through their effects on the final services and the valuation thereof (see Boyd and Banzhaf, 2007). Biodiversity – the variety of genes, species and ecosystems – holds a special position in these guidelines. Biodiversity is important to guarantee a continued delivery of ecosystem services over the long term and for maintaining ecosystem resilience (Cardinale et al., 2012; Isbell et al., 2017).

3 Two CBAs without biodiversity points

In 1993 and 1995, the water levels in the major Dutch rivers Rhine, Meuse, Waal and IJssel rose to such levels that serious breaching of river dikes was only just avoided. The projects 'Room for water' and 'Room for the

[4] Act on environmental impact assessment, Directive 85/337 EEC.
[5] Recently, also the discount rates to be used in Dutch CBAs have been changed. In 2016, it was decided to reduce the official discount rate from 5.5% to 3%. For nature, an annual relative price increase of 1% is prescribed (Werkgroep Discontovoet, 2015 and Koetse et al, 2018). As a consequence, the net effect for nature is a discount rate of 2%.

river' meant a new flavor on the Dutch menu of preventive water management policies: spatial adjustments to increase safety. Two evaluation studies of these projects characterize how nature was included in cost-effectiveness analysis in the years before biodiversity points were introduced.

CEA comparing four strategies for improving safety along the rivers and coast

The first study refers to a quick-scan cost-effectiveness analysis (CEA) [6] of a set of projects for improving safety along the rivers and coast (Stolwijk and Verrips, 2000). Table 3.1 provides an overview of the monetary costs and benefits of water safety for four project alternatives.

Table 3.1 A cost-effectiveness analysis of four projects in the lower river-region for increasing safety (Stolwijk and Verrips, 2000, table 8, p. 55)

	Rerouting of Meuse	Rerouteing of Waal	Changing discharge distribution	Raising dikes
Net annual monetary benefits (bln euro)	0.88	0.90	0.93	less than 0.93
Non-monetary effects				
quality of environment	+	+	++	
spatial beauty	+	+	++	-
social consequences for farmers	-	-	-	
flexible water management	+	+	++	-

Next to monetized cost and safety benefits, four different types of non-monetary effects were taken into account: quality of landscape spatial beauty, quality of environment (including biodiversity), social consequences for farmers and flexible water management. The scores in terms of a simple ordinal scale (five point Likert scale) were assessed by experts. Insufficient information was available to estimate the monetary value of these non-monetary effects.

The approach provided some evidence that the spatial adjustments proposed in the alternatives (rerouting of the river Meuse, rerouting of the river Waal and changing the discharge distribution over various rivers) had more positive environmental effects than the conventional approach of raising dikes; in particular changing the discharge distribution would have positive effects on the environment according to the experts. However, the scores by the experts were not transparent, e.g. it was not clear which criteria they had used to assess the change in the quality of environment. As a consequence, these expert scores were not very informative for redesigning the plans to better mitigate negative impacts or exploit potentials for co-benefits.

Four-dimensional cost-effectiveness analysis

The second study refers to an assessment of 600 specific policy measures and four packages of policy measures as part of the project Room for the river by Ebregt et al. (2005). These policy measures were very heterogeneous, ranging from deepening trenches, moving dikes further away from the river, introducing extra channels, rerouting rivers and raising dikes. They had a broad range of effects, many of which could not be

[6] A CEA is a CBA in which a specific purpose, like a target for extra transport capacity on a road, a water safety norm, an emission goal or a nature policy standard, is defined in advance and only the net benefits of policy proposals that meet this purpose are compared. The distinctive feature of CEA is that the costs and benefits of meeting the specific purpose are ignored.However, if one of the policy alternatives scores better than the target for the specific purpose, these extra benefits of this policy alternative should also be included in the CEA. Furthermore, in case the net benefits of meeting a specific targeted purpose may be clearly negative, it is often wise not to take this purpose for granted and to conducting a full CBA, i.e. including the costs and benefits of meeting that specific purpose.

well translated into monetary terms. For that reason, a so-called four-dimensional cost-effectiveness analysis was developed. For all investigated measures, four types of benefits were distinguished:

- Extra safety in terms of a reduction of high water level to the target high water level in m^2;
- Extra landscape with high environmental quality (biodiversity) in hectares;
- Extra landscape with spatial beauty per kilometer along the river;
- Extra landscape attractive for leisure activities per kilometer along the river.

For the three different types of landscape effects, the impact of the policy measures was estimated as the change in acreage of a wide range of ecotopes. This was used to create an expert opinion on biodiversity, spatial beauty and leisure effects. The measure for biodiversity can be seen as a precursor of the biodiversity points method discussed in section 4. Similar types of ecotopes are distinguished as in the biodiversity points approach, but here weighting was done through expert review instead of through a predefined set of quality and weighting indices. The predefined weighting indices make the biodiversity points more transparent and objective.

For all 600 measures, information on their costs per unit of benefit was compared to the standard cost per benefit. The typical cost rate for an extra hectare of landscape with high environmental quality was 230 thousand euro. This was much higher than the average costs per ha for increasing environmental quality in the Netherlands. Hence, combining extra safety with environmental development did not seem to be very cost-effective.

4 Three CBAs with biodiversity points

The unsatisfactory and arbitrary way of incorporating biodiversity in CBAs encouraged Sijtsma et al. (2009) to develop an alternative approach, jointly with ecologists and economists. They proposed a cost-effectiveness analysis (CEA) in which the net benefits of those elements that can be valued are compared with the change in so-called *biodiversity points*. The biodiversity point method, sometimes also referred to as the Threat-weighted Ecological Quality Area Method (T-EQA method; Puijenbroek et al., 2015), measures the impact on the amount and quality of biodiversity in a standardized way (Sijtsma et al., 2009; Jaspers et al., 2016).

This biodiversity points approach is increasingly being applied in Dutch CBAs, resulting in more and more insight in what would be reasonable costs for obtaining an additional biodiversity point. This is in particular useful to compare the cost-effectiveness of project alternatives with respect to their impact on biodiversity. For assessing the net benefits of projects, it is also more informative than qualitative or ordinal expert opinions on a policy measure's impact on biodiversity. However, biodiversity points are not expressed in monetary terms. As a consequence, they do not have an impact on the net benefits in monetary terms or on the benefit-cost ratio in monetary terms. This may imply that in the political decision-making process they may be neglected or play only a subsidiary role. This will occur in particular when the overview-table of a CBA only compares alternatives in monetary terms.

How to measure biodiversity points?

The biodiversity points are calculated by multiplying three components:

- The area of natural or semi-natural ecosystems affected (in hectares or square kilometers);
- The ecological quality of each area;
- A weight factor per type of ecosystem, reflecting the contribution of the ecosystem to species richness at national, European or global level, which depends on the species present in the ecosystem and their threat level.

The ecological quality is measured by an intactness or robustness score, in a range from 0 to 1. This measure is determined for each of the relevant ecotopes based on the number of characteristic species present in the area relative to their presence in an intact ecosystem. These ecotopes and characteristic species are derived from the universal set of biodiversity indicators (Convention on Biological Diversity, 2004), the more detailed European set of biodiversity indicators (EEA, 2007) and the Mean Species Abundance used in UNEP's Global Environment Outlook. For this, national reference lists containing the species in an intact ecosystem are available, e.g. for the Netherlands.[7] In Europe, for the Habitat regulation (EC, 1992) and the Water Directive (EC, 2000), each EU-member country had to assess the ecological quality of ecotopes in comparison to a healthy ecological condition. So, this is already roughly similar to providing intactness or robustness scores for ecological quality.

Environmental impact assessments (EIAs) generally provide the necessary information on ecological quality, before and after the policy intervention. This information per ecotype of the number of characteristic species in the area can then be translated into ecological quality scores, before and after the policy intervention. Multiplying the ecological quality scores for the different ecotopes by the acreage of their area gives the Ecological Quality Area score (EQA) per ecotope.

Finally, the EQAs of the ecotopes are multiplied with standardised weight factors that indicate the threat level to the ecotope. This threat level is related to the relative number of red list species in the ecotope. Extremely threatened ecotopes have the highest weight, while commonly occurring ecotopes with common and not threatened species have the lowest weight. As a result, an intervention in a highly threatened ecotope results in a higher score than a similar intervention in a non-threatened ecotope. For example, salt marshes have a weighting factor of 2.4, nutrient-poor peatlands and moist heather lands have a weighting factor of 1.2 and agricultural grasslands have a weighting factor of 0.4.

Determining the weighting factors is not fully straightforward and different methods and data sources are possible (see Sijtsma et al., 2009). However, most important is that these weights are standardized for each country and based on systematic ecologic data collection which is objective and transparent, e.g. similar to how CO_2-equivalents are used to aggregate different types of emissions or how different health effects are summarized by the indicator Disability Adjusted Life years (DALY's).

Biodiversity points or T-EQA is defined as:

$$Biodiversity\ points = \sum_{i=1}^{n} Area_i \times Quality_i \times Weight\ factor_i$$

With $i \in \{1,\dots,n\}$ the different types of ecotopes or nature types.

[7] Reference lists of 'species pursued' have been prepared for monitoring the Dutch nature policies and contain the pursued biotic and abiotic characteristics of each nature type. Using the reference lists, for each nature area measurable objectives can be set and monitored. They provide the basis for conservation planning and management and national and European .

An advantage of the biodiversity point method is that decision-makers have a single objective measure to compare biodiversity effects of alternative interventions. For some questions, this is more useful than the range of impacts shown by an EIA. Where an EIA is useful to assess whether legal norms are exceeded, it is not very useful to compare e.g. an intervention impacting fish stocks with an alternative intervention impacting water quality in an adjacent area. The scarcity based weighting of the biodiversity points allows decision-makers to compare these incomparable impacts.

Three examples can illustrate the biodiversity point method.

CBA of increasing biodiversity by raising groundwater levels

For three areas in the peatlands in the Netherlands, two alternatives for raising the groundwater levels are compared in a CBA (Witteveen & Bos and Arcadis, 2006). Both alternatives improve biodiversity. The second alternative leads to the highest levels of aquatic biodiversity. In this CBA all effects, including effects on biodiversity, were monetized on the basis of a survey on willingness-to-pay. The scientific basis for the willingness-to-pay values, however, was rather weak. The study did not properly present the biodiversity change to the respondents and was not clear about the population impacted by the change proposed. This is a well-known risk of badly designed stated preference research.

Table 4.1 Results from a full CBA and a CBA presenting biodiversity points separately

Area	Alternative	Value of biodiversity (mln euro)	Biodiversity points
Krimpenerwaard	Alt.1	0.5	1352
	Alt.2	0.5	1751
Groot Wilnis Vinkeveen	Alt.1	1.2	808
	Alt.2	1.2	1730
Wormer and Jisperveld	Alt.1	0.5	976
	Alt.2	0.5	1691

*direct costs minus avoided costs. Source: Sijtsma et al. (2009).

Sijtsma et al. (2009) recalculated the results, but now with biodiversity points. Table 4.1 presents the results of this study, with the biodiversity effects given both in monetized values as well as in biodiversity points. Monetized values hardly differ between the two alternatives, whereas the biodiversity points clearly show that the alternatives have different biodiversity impacts. Next to that, the area having the largest monetized value does not result in the highest gain in biodiversity points.

The revised information provides more relevant information to policy makers than the original information in the badly designed stated preference research. It enables them to distinguish between the effects on nature of both alternatives. Moreover, it allows them to evaluate for which alternative and in which area they obtain the highest extra biodiversity per euro invested. This information in biodiversity points may be supplemented with a more qualitative description of the impacts on nature of the various alternatives. The information in biodiversity points could also be the input for an alternative stated preference research: what is the willingness to pay for such points?

CEA for the reconstruction of the Afsluitdijk

One of the first major studies using the biodiversity-points methodology was the CEA of the Afsluitdijk by Grevers and Zwaneveld (2011). In order to meet legal safety standards of flooding once every 1/10.000 years, this enclosure dam needed fundamental reconstruction. The dam should also continue to meet two other functions: managing the water level in the IJsselmeer and providing good connections for transport by car and by ship. This renovation could be combined with new functions with respect to nature, e.g. green dikes and special sluices for fish.

The CEA showed the effects on nature in two different ways: the extent to which legal environmental protection standards were met and the score in biodiversity points. In contrast to the perspective of minimal legal standards for the environment, the score in biodiversity points does not only look at negative effects on the environment, but also takes into account how much extra biodiversity can be created.
In order to calculate the biodiversity points for the plans to renovate the Afsluitdijk, the impact area and the different habitats had to be distinguished and the quality and relative weight of each habitat had to be assessed. The impact area considered was 3 km on both sides of the 33 km long Afsluitdijk. Table 4.2 provides an overview of the different habitats in the area, their weight scores and their current, pre-intervention quality scores. The quality scores were based on earlier estimates for the European Water Framework Directive.

The table shows that the ecological quality varies from zero for paved surface to 3.4 for areas with a sweet-salt water gradient. The current situation is 11,770 biodiversity points, for an area of 19,000 ha. The average ecological quality is 37.5 percent and the average weighting factor is 1.6.

This table shows that the current quality of the shoreline and marshes in the Makkumer Noorwaard is 54 percent. Its weighting factor is 1.6. With an area of 300 ha, these marshes have 300 x 1.6 x 0.54 = 259 biodiversity points. Suppose that you build an additional 100 hectares of marshes at the expense of shallow sweet open water, then you gain 100 x 1.6 x 0.54 = 86.4 biodiversity points, but lose 100 x 1.3 x 0.35 = 45.5 biodiversity points.

Table 4.2 Habitats surrounding the Afsluitdijk (Wessels et al., 2011)

Type of habitat	Relative weight	Quality of current situation (percentage)
I. IJsselmeer and Afsluitdijk		
Landzone		
roadsidegrass	0.4	13
Makkumer Noorwaard	1.8	55
paved road surface	0.0	
Shoreline and marshes		
Makkumer Noorwaard	1.6	54
Brackish	2.4	
brackish and sweet-salt gradient	3.4	
Open water		
shallow and sweet	1.3	35
shallow and brackish	2.0	
shallow, brackish and sweet-salt gradient	3.0	
deep and sweet	0.7	34
II. Waddensea (north side of Afsluitdijk)		
Saltmarsh including pioneer and climax stages and sweet-salt gradient	3.4	
Saltmarsh including pioneer and climax stages	2.4	

Dry falling sand plates including mussel banks	2.0	52
Permanently flooded sand plates including mussel banks	2.5	40
Gullies	0.7	37
Land zone, roadside grass	0.4	

According to table 4.3, only some alternative interventions and options have substantial impact on nature, e.g. the natural enclosure dam, the 500 ha extra marshes and the fish sluice. They either result in larger areas of rare habitat types (with high weighting scores) or result in substantial quality improvements. The table also shows that the option Green Afsluitdijk has a clear positive effect on biodiversity: an increase of 1,600 biodiversity points. An interesting result was that nearly the same amount of biodiversity points (1,500) could be obtained by constructing a fish sluice in the Afsluitdijk, but at only a fraction of the costs: not 550 mln euro but 10 mln euro. Hence, fish sluices were much more cost-effective for improving biodiversity.

This CEA was well received by policy makers. The results were almost completely adopted in the final decision of the Dutch Cabinet (Zwaneveld et al., 2012). The option Green Afsluitdijk was rejected and it was decided to construct a fish sluice. Subsequent political decision-making led to a much more advanced and fish-friendly, but also much more expensive fish sluice (35 mln euro).

Table 4.3 Renovating the enclosure dam: cost-effectiveness of various options for extra biodiversity (see Wessels et al, 2011)

Alternatives	Biodiversity points	Costs (mln euro)	Of which: costs for biodiversity (mln euro)	Cost-effectiveness (mln euro per biodiversity point)
Current situation	11770			
Major alternatives	Difference with current situation			
2100-Robust	-30	1640		
Basic alternative	-10	1390		
Monument in balance	0	1560		
Natural enclosure dam (Green Afsluitdijk)	1600	2670	550	0,34
Waddenworks	-330	1630		
Supplementary options				
500 ha Marshes (option for Waddenworks)	3600	135	135	0,04
Brackish water zone (option for Natural enclosure dam)	1330	240	240	0,18
Fish sluice (option for all major alternatives)	1500	10	10	0,01

CEA for the management of the water level in the IJsselmeer

A second study that adopted the biodiversity point method, but in a modified and simplified way, was the CEA on raising the water level in the IJsselmeer by Bos et al. (2012). This CEA compared various long term alternatives. The two basic alternatives were:

- Raising the water level in the IJsselmeer in line with the rise in the sea level (L4);

- Not raising the water level in the Ijsselmeer but installing massive pumps at the Afsluitdijk (L1).

These basic alternatives and various supplementary alternatives were compared for two climate scenarios: the warmest climate scenario (W+) assumes that the sea level rises with 85 cm in the period 1990-2100, while the average climate scenario (G) assumes a sea level rise with only 35 cm (KNMI, 2006).

Table 4.4 Summary table for the CEA on raising the water level in the IJsselmeer, see Bos et al. (2012)

Alternative Climate scenario[1]	L1 W+ / G	L3a W+ / G	L3b W+ / G	L4 W+ / G
A. Costs of interventions plus costs for nature compensation (mln euro)				
Investments	1094 / 603	1882 / 1113	1882 / 1113	1882 / 1113
Remaining flood risk	971 / 835	1381 / 1204	1628 / 1419	1256 / 1089
Avoiding environmental damage:				
A.1 Prevention	4	282 /24	322 / 59	158 / 15
A.2 Compensation	15	242 /26	256 / 55	153 / 15
B. Risk of not meeting legal conservation standards in a situation without nature compensation				
Natura 2000:				
- birds with risk not to meet standards	69%	86% / 71%	86% / 74%	83% / 66%
European WFD[3]:				
- % water plants	-	-- / -	-- / -	- / -
- % shell fish	+	- / =	- / =	- / +
Fish migration				
- risk in spring	Limited	Real / Real	Real / Real	Real / Limited
C. Loss of biodiversity without nature compensation for the IJsselmeer; current situation = 100%				
Fish-eaters	48%	43% / 42%	43% / 43%	43% / 48%
Shellfish-eaters	35%	21% / 31%	21% / 31%	18% / 34%
Plant-eaters	11%	6% / 9%	5% / 9%	11% / 12%
Other birds on land or in reed	5%	4% / 4%	2% / 5%	6% / 6%
Total	99%	73% / 87%	71% / 88%	77% / 100%

Notes: 1. Project alternative L1: the water level in the IJsselmeer does not rise with the sea water level, but pumps are installed to pump the surplus water from the IJsselmeer to the Waddensea. L4: IJsselmeer water level rises with sea level rise; L3a,b: like alternative 4, but with 50 cm extra water in spring or with 80cm extra water in spring, respectively. 2. W+ scenario is the warmest climate scenario, the G scenario is the average climate scenario; 3. WFD = Water Framework Directive.

The effects on nature were incorporated in three ways:

- costs of avoiding environmental damage (approach A);
- risk of not meeting legal conservation standards Natura 2000, European Water framework directive and fish migration (approach B);
- biodiversity points method based only on quality percentages of some representative bird species (approach C).

Approach A provides estimates of the costs of avoiding any environmental damage. The entire lake is categorized as protected area in which interventions causing damage to nature values are prohibited unless the intervention would be a matter of significant social importance. Especially the shallow parts of the IJsselmeer are important for biodiversity. These parts can be protected against a rising water level by constructing a sand barrier (approach A.1). Environmental damage can also be avoided by transforming agricultural land into an area with natural value (approach A.2).

The CEA showed that for all long term policy alternatives the costs of these two types of avoiding environmental costs are of similar size and were clearly higher in the warmest climate scenario (W+) than in the average climate scenario (G). For example, in case the IJsselmeer water level will rise with the rise in the sea level (L4), constructing a sand barrier will be about 10 times more expensive in the warmest climate scenario than in the average climate scenario: 158 mln euro versus 15 mln euro.

The CEA indicated also that the choice between the different long term policy alternatives is not affected by taking into account these two types of environmental costs, because the differences in costs of investment and in the expected value of the remaining flood risk are much higher than those in environmental costs.

Approach B showed the probability that legal conservation standards were not met. From this perspective, raising the water level in the IJsselmeer (see table 4.4, L3a, L3b and L4) is in the warmest climate scenario clearly more risky for birds, water plants, shell fish and fish migration than installing pumps (L1).

Thirdly and finally, approach C measured the effects on biodiversity points without any additional policy measures. For quantifying the biodiversity effects, an approach related to, but somewhat different from, the biodiversity points approach was followed. Calculating biodiversity points for water quality related issues is not yet as far developed as for land biodiversity. This is due to the difficulty to define the impact area. Quality changes not only have an effect on the area where the changes take place but on a much larger area. Moreover, the quality indices and the weight factors are very much context dependent.

Not in all of the shallow parts of the IJsselmeer the same species are scarce. Quantification of the impact on biodiversity and the weighting factors were especially based on birds that feed themselves with fish from the IJsselmeer. These bird species can be seen as an indicator species for water quality and for biodiversity in water ecosystems like the IJsselmeer, as they are at the end of the various food chains. For these birds in the IJsselmeer, also reliable and detailed information is available. The model Habitat (Deltares, 2012) was used to calculate the change in four types of areas (ecotopes): open water, water with shellfish, water with waterplants, cane and bare ground. These ecotopes were then linked to the birds that forage there: shellfish-eaters (e.g. all kinds of ducks), fish eaters, plant eaters, cane birds and bare ground birds. Table 4.4 shows that the effects on biodiversity would be significant especially in alternative L3 and L4 and especially for the warmest climate scenario.

According to this cost-effectiveness analysis, installing giant pumps at the Afsluitdijk (L1) is over one billion euro (in net present value) cheaper than allowing the water level to rise with the sea level (L3a, L3b and L4). About 20% of this difference is due to the absence of costly measures to prevent damage to nature in alternative L1. This conclusion is reinforced by the effects on biodiversity: especially for the warmest climate scenario, installing pumps is clearly less detrimental for biodiversity than allowing the water level to rise with the sea level. This conclusion also holds when the differences in fresh water supply are taken into account[8].

[8] This is not shown in table 4.4.

5 Conclusions and looking forward

The way nature has been incorporated in Dutch CBAs has changed over time: from CBAs in which major impacts on nature were not even mentioned to CBAs in which the impact on ecosystem services are valued as much as possible and effects on biodiversity are measured in biodiversity points. In some earlier CBAs, like Stolwijk and Verrips (2000) and Ebregt, Eijgenraam and Stolwijk (2005), ordinal scaling or quantitative measures were used, like the change in the number of hectares of high environmental quality. But no detail was shown and the rarity of the species in the habitat was not taken into account. In recent Dutch CBA studies, like the revisited CBA on raising groundwater levels (Sijtsma et al., 2009), the revisited CBA on extra lanes for the highway Schiphol-Amsterdam-Almere (Sijtsma et al., 2009)[9], the CEA on Renovating the enclosuredam (Grevers and Zwaneveld, 2011) and the CEA on policy measures to enable wildlife crossing of roads, channels and railway tracks (Sijtsma et al., 2018), biodiversity effects are quantified in terms of 'biodiversity points'. In the CEA on the management of the water level in the IJsselmeer (Bos et al., 2012), a related but somewhat different approach was used. In the Netherlands, the biodiversity point method is recommended by the national guidelines on CBA (Romijn en Renes, 2013 and Klooster et al., 2018).

Biodiversity points are a practical and transparent method to quantify the impact of policy measures on biodiversity. They are especially useful for policy measures that have a major impact on ecosystems, such as nature policies or infrastructural works near nature or protected areas. They can be very helpful to formulate more nature friendly or cheaper policy alternatives, or to find more cost-effective compensation measures. The applicability of biodiversity points differs for different types of nature. It is more difficult for water quality related biodiversity (cf CEA on the IJsselmeer) than for land biodiversity (cf CEA on the Afsluitdijk), as the impact area is larger and more difficult to define. For assessing the net benefits of projects, biodiversity points provide a standardized quantitative summary measure for the impact on biodiversity. This biodiversity measure can be decomposed into its constituent parts, is based on acreage of the impact area, internationally standardized ecological quality indicators and nationally standardized threat weights and can be checked on its consistency of application for various CBAs. For assessing the overall effects of a project, this is more informative than qualitative or ordinal expert opinions on a policy measure's impact on biodiversity; these are generally not standardized and comparable for different CBAs and cannot provide an indicator of change in biodiversity per euro invested.

Despite the advantages of using biodiversity points in cost-benefit or cost-effectiveness analyses, their use remains modest. Only few Dutch CBAs actually use them. One reason is that they do not give a very intuitive measure of biodiversity. Only by applying them regularly, the number of biodiversity points, or the biodiversity points gained or lost per euro invested, become intuitively appealing notions.

The use of biodiversity points can be advanced by providing overviews of their costs per point for various types of nature at various locations. This overview can give concrete examples of relatively cheap interventions for improving or protecting nature (e.g. a fish sluice in the Afsluitdijk) and much more expensive ones. The overview can also discuss the factors determining these differences in cost-effectiveness. If such an overview is available, this would be a great help for assessing biodiversity points in another CBA or CEA.

[9] This is a major infrastructural work costing about 4.5 bln euro. The effects in biodiversity points were calculated for 4 project alternatives. The most environmental friendly alternative would include transforming the aquaduct into an eco-aquaduct by adding a 70 meter wide lane for crossing animals. This would lead to a benefit of 40 biodiversity points. Its extra costs could not be calculated, because this alternative was included only in the EIA and not in the CBA.

The value of biodiversity points may also be investigated by surveying the willingness to pay for such points. The quality and weighting factors per ecosystem type can be replaced by monetary unit values that reflect peoples' preferences over maintenance of these ecosystems, in this way reflecting the contribution of each ecosystem and the ecosystem services it provides to welfare. As argued above, this requires more insight into the welfare contributions of the various ecosystems. This can then be compared with the results from surveys on all kinds of nature development and landscape types (see e.g. Bateman et al., 2006 and Liekens et al., 2013). In future CBAs, such information on the costs and willingness to pay for biodiversity may be used to incorporate also reasonable estimates in monetary terms for changes in biodiversity.

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