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Kåre P. Hagen and Gro Holst Volden (editors)

Environmental Impact of Large Investment Projects

An Anthology by 16 Norwegian Experts

Concept report No 48

 **NTNU**
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Environmental Impact of Large Investment Projects: An Anthology by 16 Norwegian Experts

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English summary

Introduction

Major investment projects can affect the environment in different ways, in the short or long term. The severity and uncertainty of their impact, and the geographical extent, may vary. The consequences can be negative, for example in terms of emissions that reduce water and air quality, the destruction of recreation areas, or the deterioration of the climate and biodiversity. However, they can also be positive, such as in the case of investments in conservation of the same assets.

The topic of this report is how environmental impacts are addressed in project analyses. To ensure efficient use of resources, cost-benefit analyses (CBAs) are often carried out, in which the environmental effects should ideally be included in the same way as other costs and benefits and translated into monetary value. There are various valuation techniques for environmental and other public goods. In some cases, these provide a good handling of the impacts. In other cases, they do not fully cover them. Some mechanisms in nature are so complex that we do not fully understand them with current knowledge. In light of scientific uncertainty coupled with risk aversion, in some cases it may be best to postpone a project that could potentially harm the environment until more accurate and relevant information is available. This is referred to as the precautionary principle. CBAs have other inherent weaknesses, such as distributional concerns not being taken into account, including impacts on later generations that ‘disappear’ due to discounting.

This report presents some recent Norwegian contribution to the literature of project analyses, from 16 of the leading experts on environmental and project analysis. The contributions are not limited to theoretical and methodological issues, but also show how environmental impacts are handled in practice.

In the opening chapter the two editors, Kåre P. Hagen and Gro Holst Volden, provide an introduction to externalities as phenomenon and different types of environmental costs, and discuss possible ways to solve this type of market failure. They also present a summary of the individual contributions.

The anthology is divided into three sections. Section 1 is about valuation of environmental goods in project appraisal, and presents different valuation techniques used today. Section 2 presents different examples and approaches from sectoral areas such as transportation, construction, petroleum, and energy. Finally, section 3 presents alternative approaches to the traditional CBA that may be considered when investments projects have serious environmental consequences.

Section 1 Valuation of environmental goods

The past 20 years have seen a rapid development in methods for economic valuation of the environment. Four chapters provide a sound overview of this development.

In Chapter 1, [Ståle Navrud](#) gives an introduction to the theoretical basis for valuation of environmental goods and the willingness-to-pay principle. As a starting point, the 'physical' change in the quality or scope of the environmental good must be established. For this purpose, the damage function approach may be used; a complementary approach in recent years has been the 'ecosystem service approach', which is presented in detail in Chapter 3. However, it is the final effect on people's health and welfare that we wish to measure, ideally in monetary terms.

The author goes on to introduce the principle valuation methods. There are two main groups of these methods: revealed preference (RP) methods and stated preference (SP) methods. They are both intended to measure people's willingness to pay for the changes they perceive. Whereas RP methods are based on people's actual behaviour in existing markets, SP methods are based on hypothetical behaviour in a hypothetical market for the environmental good. The chapter is mainly devoted to SP methods, including their applications, quality requirements, and main pitfalls. However, with limited time and resources available to perform a CBA, original valuation studies are often not realistic. The last part of the chapter therefore presents and discusses various techniques of value transfer and some important databases for original valuation studies.

In Chapter 2, [Liv Osland](#) presents a central RP method, namely hedonic pricing, which is often applied to the housing market. The market value of a house can be seen as a function of a number of attributes, including characteristics of the local environment. Clean air, an attractive view, a quiet location, and proximity to recreation areas will normally affect housing prices positively, and the opposite will affect negatively. Hedonic pricing is a method that uses the variations in housing prices to infer values of the different local environmental attributes through econometric analysis.

Hedonic pricing is widely used internationally, but the number of Norwegian studies is limited, despite the fact that Norway has a free and largely unregulated housing market, in which a large share of the population owns the house in which they live. Furthermore, in recent years, access to housing price data has improved considerably, in combination with exact location information in digital maps and through geocoding.

Kristin Magnussen, the author of Chapter 3, takes a closer look at the ‘ecosystem service approach’. This is a comprehensive framework for analysing and describing all of the services provided by nature, ranging from food, clean water, and medicines, to recreation services and carbon storage. A distinction should be made between the natural capital itself and the flow of services that it provides. If the quality or size of this flow is reduced, either temporarily or permanently, the value of the natural capital will be reduced too.

The destruction of ecosystems was put on the international agenda with the UN’s Millennium Ecosystem Assessment, which has described and classified ecosystem services from different habitats. Another important initiative was The Economics of Ecosystems and Biodiversity (TEEB), which was intended to promote a better understanding of the value of ecosystems, especially the economic value. TEEB has been followed up through national and international processes for identifying and valuing ecosystem services, and has led to an explosive increase in new valuation studies (especially those conducted using SP methods). In Norway, White Paper NOU 2013: 10 was submitted by the Ecosystem Service Committee (of which the author was a member), and the chapter presents the committee’s key recommendations.

In Chapter 4, Brita Bye introduces and discusses the social cost of carbon (i.e. the socio-economic consequences of greenhouse gas (GHG) emissions). These emissions differ from most other environmental costs, due to their global, long-term, and potentially extremely harmful implications. Since the damage caused is largely independent of where the emissions occur, a cost-efficient climate policy is one whereby all emissions incur the same price globally.

However, it is not clear which price path should be followed. The global marginal damage cost is very difficult to measure. One may instead calculate the marginal abatement cost associated with a binding emission-reductions target. However, the abatement cost depends heavily on the target, such as domestic targets, multinational targets, and global targets. A starting point could be the two-degree target, which the international community, including Norway, currently supports. Studies of the price path necessary to meet the two-degree target show large variations, but most of them state prices high above, for example, the EU’s Emissions Trading System (ETS) allowance price, and they show an increasing price over time.

Section 2 Handling environmental problems in selected areas

The second section of the report consists of seven chapters that examine environmental problems in selected situations, sectors, or projects. The contributions illustrate both practical and principal challenges related to the handling of environmental impacts in project analyses and more generally.

In Chapter 5, Snorre Kverndokk discusses the use of economic instruments in environmental policy. Environmental taxes and market-based solutions (such as tradable emission allowances) are increasingly being used. This implies that a price on emissions has been introduced and will ensure the cost-efficient fulfilment of environmental objectives. If the target also reflects the population's willingness to pay to avoid emissions, the price can be used directly in economic analyses.

Kverndokk draws on a large body of literature when he discusses taxes versus market-based solutions. Issues such as uncertainty, distributional concerns, and market power in allowance markets may be relevant. He also mentions moral arguments against tradable allowances. The EU's ETS for greenhouse gas emissions has not worked as intended, in that a large excess of quotas has built up and the price is very low. There is also an inherent challenge that such systems have limited duration and therefore the incentives for investments in emission reductions towards the end of the period covered by the system are small. Most economists seem to conclude that a tax is preferable in climate policy, and a global carbon tax is the ideal.

In Chapter 6, Harald Thune-Larsen discusses climate challenges within the framework of the transport sector. The emissions from this sector are large and increasing. This is particularly the case for aviation, but overall it is still road traffic that accounts for the largest emissions. With a traditionally strong relationship between GDP and transport volumes, the reference scenario is that traffic will increase by more than 50% between 2010 and 2050. Improved energy efficiency will limit the increase in emissions in the first half of that period, but stronger measures must be implemented in order to achieve the reductions that experts believe are necessary.

Thune-Larsen presents a number of relevant measures and their effects on emissions (based on simulations with transport models). He shows that economic instruments such as a CO₂ tax or an allowance price will reduce emissions if the price is high enough. Emissions can be further reduced in combination with, for example, differentiated vehicle taxes and parking fees in cities. However, he warns that steadily improved roads with higher speeds and capacities, as well as major investment projects at airports, will limit the effects of such measures. Increased subsidies for public transport are not necessarily a cost-efficient measure. When it comes to freight transport, the best solution seems to be a combination of optimal pricing and an infrastructure that enables higher frequency and transshipment possibilities by sea and rail.

Chapter 7 is written by Aud Tennøy, who elaborates on emission-reduction targets in the transport sector, and she compares with practical policies in urban areas. In Norway there is a clear goal not to increase car traffic in urban

areas. An active land use policy is required to attain this goal, one that facilitates walking, cycling, and public transport. This normally implies dense cities with short travelling distances, yet instead we are seeing a development that facilitates urban sprawl and constant growth in traffic.

Tennøy discusses various explanations for this paradox, based on her doctoral work. As an example, throughout the chapter she refers to the E18's west corridor, which passes through Oslo, where there is now a plan to expand the road capacity, which would lead to a significant increase in car traffic. One explanation for the above-mentioned paradox is the limited knowledge among planners, another is the conflicting objectives that individual planners have to deal with. Yet another explanation is the institutional and organizational conditions – there is a need for coordination across sectors, levels, and administrative boundaries. Today, each actor has a narrow focus on their own needs, and the public road authorities are often highly dominant in this respect.

In Chapter 8 Knut Einar Rosendahl discusses the environmental impacts of investments in renewable energy technologies. Renewable energy is going to be important in order to obtain the necessary reductions in greenhouse gas emissions. However, according to economic theory it is far better to tax the negative externalities directly (e.g. GHG emissions) than to subsidize solutions with 'less harmful consequences'. Renewable energy, too, may have some negative environmental impacts, such as those related to interventions in nature.

However, there is an argument for providing subsidies when technologies are new and immature. Private companies do not have the incentives to invest sufficiently in R&D and piloting, due to positive externalities (part of the benefits may be reaped by others). In addition, future climate policy is uncertain. Rosendahl summarizes recent literature that shows how subsidizing the development of green technologies may make economic sense. However, subsidizing energy *production* is another question, which is further complicated when we take into account the effects of other simultaneous instruments, such as taxes and emissions trading schemes.

Chapter 9, written by Igor Sartori and Inger Andresen, examines the climate impact of buildings. Since the oil crisis in the 1970s there has been a strong focus on reducing energy consumption in buildings in Norway, and the Government's requirements for new buildings have become increasingly strict. The authors present the status of the research in this area. The ideal is the zero-emission building – a building with minimal needs for energy and that may even be a part-time energy supplier. It is important to take also greenhouse gas emissions from *materials* into account, and these will be

affected by the selection of materials, amount of materials, reuse, and transportation and maintenance requirements.

Currently, available data on the costs of constructing zero-emission buildings relative to standard buildings are minimal. Studies suggest 10–15% additional costs, but most of the data come from demonstration projects. The cost of installing solar systems or other renewable energy sources makes up a large proportion of the additional cost, but it has been decreasing over time, and the authors believe that low- or zero-emission buildings will eventually be cost-efficient for house owners. The total potential for energy and emission reductions is significant, and will free electricity for activities that are currently based on fossil fuels (such as transport), or for export.

Jostein Lillestøl, the author of Chapter 10, takes a closer look at the petroleum sector. In this sector, environmental and risk considerations are given considerable weight, including the risk of oil spills. The industry itself has largely been the agenda-setter for conceptual and methodological developments in risk management, it has the precautionary principle as a basic premise, and has developed a strong safety culture. This has resulted in an implicit value of a statistical life that is much higher than in most other sectors. A key explanation is that the industry depends heavily on trust from the authorities and the population.

The chapter presents some key risk concepts and a broad picture of the emergency preparedness for oil spills in Norway, which comprises the regulatory framework, the industry's own efforts, and public emergency preparedness in collaboration with the private sector. Lillestøl also presents the tools and methods used to evaluate and prioritize environmental resources, in non-monetary terms. The 'value' of the resources is held up against pre-defined acceptance criteria for environmental risk. Thus, there is a consistent system for assessing environmental resources, but without directly involving the population's willingness to pay.

The final chapter in this section of the report is written by Steinar Strøm. It presents and discusses the highly controversial construction of a new overhead power line through the scenic natural area of Hardanger a few years ago. Opponents had demanded invisible, underground power cables. The willingness to pay in order to avoid a visible power line was clearly very high in some groups. However, the additional cost of the underground cable option was estimated to 1.4-2.4 billion NOK.

The author adopts a critical perspective on the project and the CBA that was performed. The Norwegian energy agency concluded that an overhead power line was the most profitable alternative. However, no attempt was made to

estimate the willingness to pay to avoid the lines. Strøm illustrates how different alternative combinations of willingness-to-pay per person and the number of persons who valued the area would have resulted in the power line alternative becoming unprofitable. He believes that a third alternative would have been more profitable than either an overhead power line or an underground power cable, namely a compensation plant providing voltage support and increasing the transmission capacity in the existing network. This alternative would have been much cheaper and would have given an option value compared to building new lines.

Section 3 Other approaches than the cost-benefit analysis

The third and final section of the report consists of two chapters that present other perspectives than the economic one, in which the ideal is to estimate the willingness to pay for an environmental good or ecosystem service.

In Chapter 12, Fred Wenstop presents the multi-criteria decision analysis, which is an alternative way to assess and compare the effects of a project, including its environmental effects. This method avoids the weighting according to the population's willingness to pay for the impacts, which can be difficult or very costly to measure, is often unreliable (since people are not often in a position to assess different types of environmental impacts in monetary terms), and there are ethical concerns (rich people count more than poor people, and today's generations count more than future generations).

A multi-criteria decision analysis is based on a set of relevant targets, and it is rather easy to implement because it only requires a panel of decision-makers or experts. However, there are some serious pitfalls, the most important being lack of legitimacy. It is decision-makers' preferences that we seek to measure, but in practice a panel of experts is used in the valuation process. It may be helpful to use several panels to see whether there are discrepancies in how they value the effects.

The author presents four examples of the method being used on projects with significant environmental impacts in Norway. In two of the studies, the analysis was part of a larger valuation study in which people's willingness to pay was also measured directly, so that the methods complemented each other.

In the last chapter, Chapter 13, Iulie Aslaksen presents and discusses the precautionary principle with a special focus on climate policy. The core of the precautionary principle is that one should act when the consequences can be serious, irreversible, or morally unacceptable, even though the actual risk is unknown. A strong version of the principle even implies an *obligation* to act. While the traditional cost-benefit analysis assumes full substitutability between environmental goods and money, the concept of sustainable development (the

strong version) assumes that there cannot necessarily be compensation for environmental goods that are lost. An important implication of this is that it becomes important to monitor the state of critical environmental resources in order to capture early warning signals.

The precautionary principle has been discussed in connection with, for example, greenhouse gas emissions, biodiversity loss, genetically modified food and investments in flood protection. Regarding climate change, the uncertainty about future development is particularly high. Over time, the IPCC process and the Stern Review has created political acceptance of the development of climate policy. However, the international climate policy is not sufficiently ambitious to achieve the targets that researchers have found necessary. The policy is thus not sufficiently in accordance with the precautionary principle.

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No 48	Investeringsprosjekter og miljøkonsekvenser. En antologi med bidrag fra 16 forskere <i>Environmental impact of large investment projects. An anthology by 16 Norwegian experts</i>	Kåre P. Hagen (ed.) and Gro Holst Volden (ed.)

www.ntnu.no/concept

Forskningsprogrammet Concept skal utvikle kunnskap som sikrer bedre ressursutnytting og effekt av store, statlige investeringer. Programmet driver følgeforskning knyttet til de største statlige investeringsprosjektene over en rekke år. En skal trekke erfaringer fra disse som kan bedre utformingen og kvalitetssikringen av nye investeringsprosjekter før de settes i gang.

Concept er lokalisert ved Norges teknisk-naturvitenskapelige universitet i Trondheim (NTNU), ved Fakultet for ingeniørvitenskap og teknologi. Programmet samarbeider med ledende norske og internasjonale fagmiljøer og universiteter, og er finansiert av Finansdepartementet.

The Concept research program aims to develop know-how to help make more efficient use of resources and improve the effect of major public investments. The Program is designed to follow up on the largest public projects over a period of several years, and help improve design and quality assurance of future public projects before they are formally approved.

The program is based at The Norwegian University of Science and Technology (NTNU), Faculty of Engineering Science and Technology. It cooperates with key Norwegian and international professional institutions and universities, and is financed by the Norwegian Ministry of Finance.

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