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Uncertainty in EIA

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Abstract

Environmental Impact Assessment (EIA) is focused on assessing possible future impacts of development proposals, and can be viewed as a risk assessment tool, which should incorporate uncertainty into decision-making. Uncertainty can also be seen as an inherent part of assessing projects *ex ante*. Uncertainty can be described generally, as well as specifically in EIA e.g., via its sources such as an uncertain project design or uncertain data. Studies have described various tools for handling uncertainty e.g., adaptive management and scenarios. Despite possible sources of and tools for uncertainty in EIA, studies have shown lacking disclosure and handling of uncertainty in EIA. This chapters reviews recent literature on EIA uncertainty and discusses the role and choices for actors in EIA concerning uncertainty. Some of the key points emerging is the discretion of actors, and the need for knowledge concerning roles and choices, as well as the need for a common language concerning uncertainty in EIA.

Introduction

Impact Assessment (IA), which encompasses EIA, can be defined as "*the process of identifying the future consequences of a current or proposed action*" (IAIA 2009 p. 1), and thus IA aims to predict "*future expected consequences of possible decisions*" (IAIA 2009, p. 1). These citations emphasise the aspect of EIA that it is an ex ante assessment dealing with the future and as stated by German sociologist Luhmann (1997, p. 161) "*the future is and will always be a horizon of uncertainty. It is not yet fixed, and can always turn out differently than expected*". Thus, EIA is inherently connected to uncertainty. Risk can be defined as "*A situation or event in which something of human value (including humans themselves) has been put at stake, and where the outcome is uncertain*" (Jaeger et al 2001, p. 17). Or put in another way, "*risk is a possibility of an outcome and implies uncertainty*" (Jaeger et al. 2001, p. 17). In reference to this, it can be argued that IA is a type of risk assessment, as it is a tool to assess the uncertain consequences or outcomes of an action where something of value is at stake. If nothing is at stake then there would be no need for an EIA to be performed. This is for example indicated in the basic principles of impact assessment published by the International Association for Impact Assessment (IAIA), where it is stated that EIA should be "*Focused – the process should concentrate on significant environmental effects and key issues; i.e. the matters that need to be taken into account in making decisions*" (Senécal et al. 1999). Suter, Barnthouse and O'Neill (1987) suggest using quantitative risk management as part of EIA because it adds an explicit treatment of uncertainty from which EIA can benefit. As such uncertainty and risk are closely connected, and when EIA is viewed as a risk assessment tool, it is important to note that "*The task of risk management is to anticipate outcomes of risk situations and to incorporate uncertainty into decision making*" (Jaeger et al. 2001, p. 18). Hence, it can be seen as part of the IA process to incorporate uncertainty into decision-making.

Uncertainty has not received major or sustained attention in EIA research. However, studies have been undertaken and research published, and in this chapter, attempts are made to gather and assemble currently available knowledge, as pieces of an unfinished puzzle. As a starting point,

different categories of uncertainty can be put forward based on e.g., types of uncertainty, sources of uncertainty, and where in the EIA process uncertainty is present. Such categories can be helpful for understanding and articulating uncertainty and thus this chapter will begin with a focus on this. The chapter will continue with sections on disclosure and handling of uncertainty, before focusing on issues of actors and uncertainty, and finally rounding off with closing remarks.

1. The nature and sources of uncertainty within and across the EIA process

Uncertainty is a broad concept; accordingly numerous frameworks can be presented to describe it. Here, focus is on research related to impact assessment or similar decision support tools. Zhu et al. (2011) distinguish between internal uncertainty related to the action under assessment and external uncertainty related to the surrounding natural and social environment. Walker et al. (2003) distinguish between epistemic uncertainty related to a lack of knowledge, and uncertainty related to inherent variability. The US Institute of Medicine of the National Academies, in a report on environmental uncertainty in decision-making, distinguishes between three types of uncertainty: inherent statistical variability and heterogeneity, model and parameter uncertainty also labelled epistemic uncertainty, and deep uncertainty meaning "*uncertainty about the fundamental processes or assumptions underlying a risk assessment*" (Institute of Medicine 2013, p. 4). An important distinction is that uncertainty can be related not only to knowledge but also to values, emphasizing the human and societal dimension which is a changeable thing (Walker et al. 2003; De Jongh 2000). Such typologies of uncertainty can be used to analyse and express uncertainty and be part of determining expedient ways of handling it. This will be further elaborated in section 3.

Various authors have contributed to understanding the sources of uncertainty in IA. Walker et al. (2003) conceptualize locations of uncertainty in model-based decision-support, while Tennøy, Kværner and Gjerstad (2006) and Larsen (2021) have worked empirically with a range of sources of uncertainty. The sources can be seen in table 1.

Study	**Sources of uncertainty**
Walker et al. (2003)	Context uncertainty: Identification of system boundaries Model uncertainty: Uncertainty about the form of the model and uncertainty from the computer implementation of the model Input uncertainty: Uncertainty in the reference system and external forces driving change in the system Parameter uncertainty: Uncertainty concerning data and calibration methods Model outcome uncertainty: Accumulated uncertainty associated with the model outcomes
Tennøy, Kværner and Gjerstad (2006)	Change in project Model errors Errors in data and assumptions Bias
Larsen (2021)	Design and technology: Uncertainty about the final design of the project and the choice of technology Construction: Uncertainty about timelines and methods for construction Data: Uncertainty about data used as a basis for calculations, prediction and assessments

	Calculations and models: Uncertainty about the specific methodology for models, assumptions and calculations of impacts Causal mechanisms: Uncertainty about what the derived consequences of predicted impacts are Values: Uncertainty about society's values e.g. expressed through attitudes, classifications or goals Related activities: Uncertainty about the status of related projects, plans, activities etc. Implementation: Whether or not the project and mitigation measures are implemented as presupposed in the assessment process

Table 1 Sources of uncertainty in impact assessment based on three studies

As can be seen in Table 1, Walker et al (2003) and Tennøy, Kværner and Gjerstad (2006) especially focus on uncertainty concerning data and modelling, while Larsen (2021) has the broadest focus. Despite this, some sources of uncertainty recur. All of the authors have pointed at uncertainty concerning modelling and data, and both Tennøy, Kværner and Gjerstad (2006) and Larsen (2021) point to changes in the project design as a source of uncertainty.

It is important to notice, that uncertainty can stem not only from the prediction process itself, but also from the implementation and monitoring phase after final statutory decisions as well as from completely separate processes concerning related activities that may e.g. be important in relation to cumulative effects. This issue is discussed by Larsen, Kørnøv and Christensen (2018), who find that it can be uncertain whether mitigation measures are implemented as described in the EIA and whether they have the anticipated effects. This is problematic when the decision is taken under the assumption that significant effects are mitigated.

2. Disclosure of uncertainty

One thing is establishing that uncertainty is a relevant issue for EIA and what the sources can be, another thing is whether these issues are reflected in EIA reports and processes – whether uncertainty is disclosed, which is explored in the following paragraphs.

2.1 The extent of disclosure

It can be viewed as part of good EIA practice to disclose "*limitations and difficulties*" (Senécal et al. 1999). Uncertainty can be viewed as such a limitation or difficulty, and even though uncertainty is not always mentioned specifically, various pieces of legislation reflect this principle. For example, the EU Directive on EIA, which is the framework for EIA in all EU member states, includes in the demands for content of the EIA report "*A description of the forecasting methods or evidence, used to identify and assess the significant effects on the environment, including details of difficulties (for example technical deficiencies or lack of knowledge) encountered compiling the required information and the main uncertainties involved*" (EU 2014, Annex IV, emphasis by author). Pavlyuk et al. (2017), have studied provisions for considering and disclosing uncertainty in EIA in Canadian legal documents. They concluded that provisions are limited and mostly in the form of guidance rather than legislation and regulation. Thus, disclosing uncertainty is part of best practice guidance, and in some jurisdictions also part of the legal framework, but the form and rigour varies.

Looking at table 1, it is clear that uncertainty can have many sources and can be present in all parts of the EIA process. However, uncertainty is important and warrants attention and action to the extent that it affects the assessment of impacts and thus makes this and the ensuing decision uncertain. This is also reflected in where in the EIA process uncertainty has been disclosed in practice. Larsen (2021) and Lees et al. (2016) find that in practice in EIA reports uncertainty is most often disclosed in relation to setting the baseline as well as the prediction and assessment of impacts. This is illustrated in figure 1.

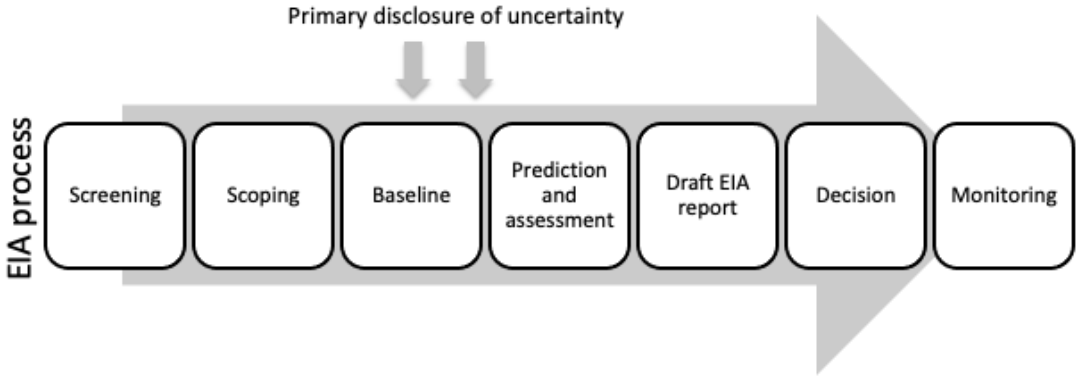

Figure 1 Where in the EIA process studies have shown that uncertainty is mainly disclosed. Based on (Larsen, 2021; Lees et al. 2016).

Despite this, several empirical studies have pointed out a lack of acknowledgement and disclosure of uncertainty in EIA in practice. Lees et al. (2016) review mitigation, follow-up and contingency plans for twelve Canadian EIAs. The focus is based on the view that uncertainty is especially relevant in these parts of the EIA. In nine of the EIAs uncertainties were expressed, however Lees et al. (2016) find that compared to the extensive nature of the EIAs, the extent and level of uncertainty disclosure, and the level of details in which they were described and discussed was low.

It might be argued that such results reflect that uncertainty is not a relevant issue for these EIAs, meaning that there is no significant uncertainty to disclose. Tennøy, Kværner and Gjerstad (2006) have studied 22 EIAs, and for 11 of these they have compared the predicted impacts with the actual impacts after implementation. This analysis shows that 29% of the predictions were deemed nearly accurate and 29% inaccurate. Despite this, uncertainty is not mentioned in 59% of the EIA reports. Another study is focussed on climate change uncertainties. According to the IAIA International Best Practice Principles for Climate Change in Impact Assessment, climate change is an environmental issue for which there is often uncertainty concerning the "*precise nature (degree, timing, etc.) of these changes*" and thus uncertainty should be addressed when dealing with climate change in EIA (Byer et al. 2018, p. 3). Larsen, Kørnøv and Driscoll 2013 studied 151 Strategic Environmental Assessment (SEA) reports and found that 60% of the reports included considerations of climate change, while only 3% (five reports) mention any uncertainty in relation to climate change. Thus, there are indications that even when uncertainty is a relevant parameter, it is not well disclosed in EIA reports.

2.2 The level and language of uncertainty

Looking at how uncertainty is disclosed in EIA reports in practice, several authors also identify and discuss different levels and use of language. Larsen (2021) with inspiration from Tennøy, Kværner

and Gjerstad (2006), Pavlyuk et al. (2017) and Lees et al. (2016), suggests that the following linguistic categories of disclosing uncertainty can be identified:

A) The explicit disclosure of uncertainty, using the word 'uncertainty' or variations e.g., 'uncertain' or 'not certain';
B) Explicit disclosure of uncertainty, not using the word 'uncertainty' or variations, but using other words such as 'unknown' or 'unclear'; and
C) Implicit indication of uncertainty using words such as e.g. 'seems', 'probably', 'expected' or 'typically'.

As an example of A) explicit disclosure, the following is from an EIA of an airport in Greenland: "*Possibly the noise limits should be lowered to 50 dB in areas with vulnerable species, because higher noise levels can have a negative influence. However, there is uncertainty concerning the effect in different habitats, since some species show a high degree of tolerance to noise*" (Kalaallit Airports A/S 2018, p. 65; emphasis added by author). As an example of B), which is explicit, but not using the word uncertainty, the following is from an EIA of a mine in Greenland: "*To what extent the low water flow in Lakseelv during mid-winter will cause the concentration of lead to exceed the GWQG value after 3-5 years of operation is unknown*" (Tanbreez 2013, p. 80; emphasis added by author). And finally, as an example of C) the more implicit indication of uncertainty, the following is from another EIA of a mine in Greenland: "*The mine infrastructure seems to be able to avoid any conflicts with the cultural heritage sites*" (True North Gems 2014, p. 5; emphasis added by author).

Some studies find no large differences between the categories and some find that there are most occurrences of categories B and C, meaning that there is very little explicit mentioning of uncertainty (see e.g. Larsen 2021; Lees et al. 2016; Tennøy Kværner and Gjerstad 2006) As Lees et al. state there is a "*widespread, and inconsistent, use of vague and unqualified terminology such as 'may', 'could', 'probably', 'maybe', or 'as soon as possible'*" (Lees et al. 2016, p. 2038). This lack of consistency makes it difficult for readers to analyse and understand when exactly there is uncertainty and how much.

3. Addressing uncertainty

The next issue to investigate is how uncertainty can be addressed. Several studies find that in current practice, when uncertainties are disclosed, they are often not actively addressed (see e.g., Lees et al. 2016). However, this needs not always be the case, as there are several approaches and examples of uncertainty being addressed in practice.

One way of viewing the issue is to distinguish between analysing and actively handling uncertainty. The former entails understanding and expressing uncertainty, while the latter entails taking various actions to deal with uncertainty. It is important to note that analysing uncertainty should be the basis for handling uncertainty.

Pavlyuk et al. (2017), find that describing, documenting or explaining scientific uncertainty concerning data, was the third most common provision in Canadian EA legislation, regulations and guidance. For example, EA guidelines from Nova Scotia emphasize that uncertainty such as that from climate change should be "*understood by decision makers; and the steps taken to address this uncertainty must be demonstrated*" (Nova Scotia Environment in Pavlyuk et al. 2017). An

example of analysing uncertainty is from an EIA report for a mining project at Killavaat Alannguat, which contains a systematic declaration of the confidence level for the assessment of each impact, focussed on whether or not there is confidence in the data. The confidence level is described as:

- 'Low' when data is weak;
- 'Medium' when data from Greenland or other parts of the Arctic point to the conclusion; or
- 'High when data form the study area or neighbouring areas are conclusive.

Thus, it is an analysis of the epistemic certainty of data on which the assessment is based.

Focussing on handling uncertainty, two general strategies can be derived inspired by literature on climate change uncertainty. One is a reduction strategy, where it is attempted to reduce the uncertainty by attaining more knowledge, for example by collecting more data, carrying out further studies or developing more advanced models (see e.g. Dessai and van der Sluijs 2007). This strategy has, for example, been shown by Pavlyuk et al (2017) to be a common provision in Canadian legislation, regulation, and guidelines on EA. It was further found by Lees et al. (2016) in three out of 12 EIA cases that uncertainties were addressed by proposing additional research.

The other strategy is a resilience strategy, where uncertainty is accepted, and it is sought to find solutions and make decisions in the most expedient manner under the uncertain circumstances. As stated by Thissen and Agusdinata (2008, p.1) "*it may be advisable to accept uncertainties and spend efforts on identifying and assessing them and on developing appropriate approaches to act in light of (irreducible) uncertainties*". This can for example be looking for decisions which are robust to different outcomes of the uncertain parameters, applying the precautionary principle or using adaptive management. As stated, analysing uncertainty can be the basis for choosing how to address uncertainty. For example, a reduction strategy can be much more suitable if your analysis show that you are dealing with epistemic uncertainty rather than variability uncertainty.

Studies and literature have suggested and shown the use of various tools for actively addressing uncertainty. Some of these are monitoring, adaptive management, worst case approaches, scenarios and the precautionary principle (see e.g. Paylyuk et al 2017; Larsen 2021).

3.1 Monitoring and adaptive management

Monitoring is an essential part of impact assessment. According to the International Association for Impact Assessment (2009, p. 1), part of the aim of impact assessment is to "Identify procedures and methods for the follow-up (monitoring and mitigation of adverse consequences) in policy, planning and project cycles". As the quote suggests, monitoring is part of a follow-up process, which also includes evaluating the monitoring data, managing and responding to issues arising from the former stages, and communicating with stakeholders (Morrison-Saunders, Marshall and Arts 2007). Throughout the follow-up process, uncertain elements of the EIA can be monitored, and appropriate action can be taken if developments turn out different than predicted. As stated by Marshall, Arts and Morrison-Saunders (2005, p. 177), "*Pre-decision EIA is predictive; focusing on an uncertain future. Follow-up can address such uncertainties and deficiencies, which are intrinsic to EIA planning and decision-making processes, thereby rationalising these processes*". Importantly, monitoring can include both monitoring impacts and

mitigation measures, making it possible to deal with any uncertainty from the implementation of mitigation measures (as included in table 1).

Adaptive management is an approach that can be used together with monitoring. It is based on the understanding that "*For many problems, it is likely that the uncertainties that confront planners will be resolved over the course of time by new information….Thus, policies should be adaptive – devised not to be optimal for a best estimate future, but robust across a range of possible futures*" (Walker, Rahman and Cave 2001, p. 283). The approach involves designing activities in a dynamic way, that make it possible to respond to changes over time, where the activity can be adjusted or re-adjusted when needed, based on monitoring and gathering of information (Walker, Rahman and Cave 2001). Adaptive management basically includes setting up monitoring of chosen issues and identifying action thresholds or triggers as well as possible actions that may be taken if monitoring shows that these thresholds are exceeded. Actions can be to change the mitigation measures accordingly. (Canadian Environmental Assessment Agency 2009; Walker, Rahman and Cave 2001)

The relevance of using adaptive management for handling uncertainty in impact assessment is stressed by Bond et al. (2015), and both Lees et al. (2016) and Larsen (2021) find examples of monitoring and to some extent adaptive management being used in EIA. For example, in the case of an EIA for a mine in Greenland, where additional mitigation measures are proposed to be launched, in case monitoring shows that set limit values for water environment are exceeded (Larsen 2021). However, in both studies it is stressed that the use of monitoring is most often not explicitly connected to uncertainty or adaptive management, and it is difficult to establish whether and how monitoring is aimed at handling uncertainty (Lees et al. 2016; Larsen 2021).

3.2 Scenarios and worst-case approach

Scenarios are generally defined as possible futures for a certain focal issue with relevance for a decision to be made. Importantly, scenarios are plausible suggestions for how the focal issue might develop in the future, as opposed to a certain prediction of how it will develop (see e.g., European Environment Agency 2009). There are multiple methodologies available for developing scenarios. However, the one most used in practice is the scenario axis or matrix approach, where drivers of change constitute axes that intersect, creating a matrix forming the overall scenarios (European Environment Agency 2009; Bishop, Hines and Collins 2007). According to the European Environment Agency (2009, p. 6) "*scenario planning has been developed as a method to represent and deal with deep uncertainty…*". Scenarios are used when the future is uncertain, and we need to plan for multiple futures to prevent being surprised and unprepared (Bishop, Hines and Collins 2007). In continuation of this, scenarios have been suggested by Duinker and Greig (2007, p. 213) as "*scenario-based approaches to forecasting environmental impacts offer a way to grapple with uncertainties inherent in predictive exercises that reach into the long-term future*".

Using a scenario-based approach in EIA might thus encompass working with multiple possible outcomes of e.g., the baseline, predictions or mitigation measures, depending on where there are uncertainties, which warrant this approach. It is important not to intermingle the use of scenarios with the assessment of alternatives for the activity under assessment, which is a key part of EIA (IAIA 2009). For example, in an EIA for development of a new urban area in the Danish

Municipality of Silkeborg, three different scenarios for the baseline of amounts and distribution of traffic in the area are established; one based on the current situation, one based on the predicted situation in 2020 and one based on the predicted amount if three planned traffic-related projects are implemented. It is then assessed what the impacts on traffic amounts and distribution will be in each of these three traffic scenarios. Unlike this, an alternative would be assessment of the impacts of different sizes of the original urban development project on traffic amounts and distribution. In general terms, scenarios can be seen as different ways the context for the development proposal can unfold, while alternatives are different ways of implementing or designing the development proposals.

A variation of the scenario approach is working with a worst-case scenario. Here, the logic of the scenario is preset to be the worst imaginable outcome, where the future is unlikely to be worse (Bishop, Hines and Collins 2007; Dewar 2002). Basically, a worst-case scenario is constructed by looking at uncertainties in the activity and for each of those determine the worst possible outcome (Dewar 2002). Pavlyuk et al. (2017) find provisions to assess or explore worst case scenarios in Canadian guidance documents, and Lees et al. (2016) find that in four out of 12 EIA cases uncertainty have been addressed with sensitivity analysis or conservative estimates, where conservative estimates correspond to a worst-case approach. A specific example where a worst-case approach is used explicitly and consistently is from the EIA for a new airport in Ilulissat: "*the assessments are based on the available information concerning the project and its activities in the construction and operation phases, and the assessments of environmental impacts are worst case assessments. In the detailed planning of the project, the design and activities will be specified, and thus the real environmental impacts may prove to be less than assessed in the present report*" (Kalallit Airports A/S 2018, p. 48). It is important to note in relation to such examples, that the worst-case approach should not be used as a pretext for inaction.

3.3 Precautionary approach

According to the precautionary principle "*Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*" (UN 1992). Thus, the principle states that when dealing with potentially significant environmental impacts, uncertainty should not be a reason to not do what is necessary to protect the environment (Science for Environment Policy 2017). The precautionary principle can be a guideline for deciding on environmental protection measures in the face of uncertainty, meaning that using a precautionary approach has a slightly different character than the previously examined approaches, which are more tool oriented. The precautionary principle is used and interpreted in various ways. One way of understanding it, as formulated by Garnett and Parsons (2017), is that there are levels of strength of the principle:

- Weak precaution: Where uncertainty does not justify inaction, and proposed environmental regulation is permitted in the absence of full scientific certainty;
- Moderate precaution: Where uncertainty justifies action, in the sense that precautionary action such as regulatory settings with large safety margins are set in place until research has reduced uncertainty; and
- Strong precaution: Where uncertainty justifies shifting the burden and standard of proof and an activity is not permitted until the proponent has proven that it is safe.

Based on this, one way of translating the use of a precautionary approach in EIA is that it entails establishing all the necessary mitigation measures without delay even if there is uncertainty concerning the impact, unless the proponent can prove that there will be no significant impact. An example of the use of a moderate precautionary approach is in an EIA of a ruby mine in Greenland. Concerning how to handle waste from the facility, it is decided that: "*Until further studies prove it environmentally safe to dispose the remains in local landfills or sewer systems, the waste will be shipped for further processing and disposal outside Greenland*" (True North Gems 2014, p. 5). Pavlyuk et al. (2017) find examples of provisions to apply the precautionary principle both in Canadian guidance and legislation. Lees et al. (2016) find that in four out of 12 EIA cases analysed, uncertainty was addressed with precautionary approaches.

This section demonstrates that there are options for actively addressing uncertainty and also examples of use. However, it also shows that it is sometimes unclear when and how the approaches and tools are used to address uncertainty and when they are used with other aims. Thus, there is a need to explicate when and how uncertainty is addressed.

4. Actors dealing with uncertainty in EIA

As reviewed in the previous sections, there are various choices made in an EIA concerning whether and how to disclose and address uncertainty when it is encountered in EIA. Based on the previous sections and the model developed by Larsen, Kørnøv and Driscoll (2013), Figure 2 shows possible pathways once awareness has been raised about an uncertainty when working on an EIA.

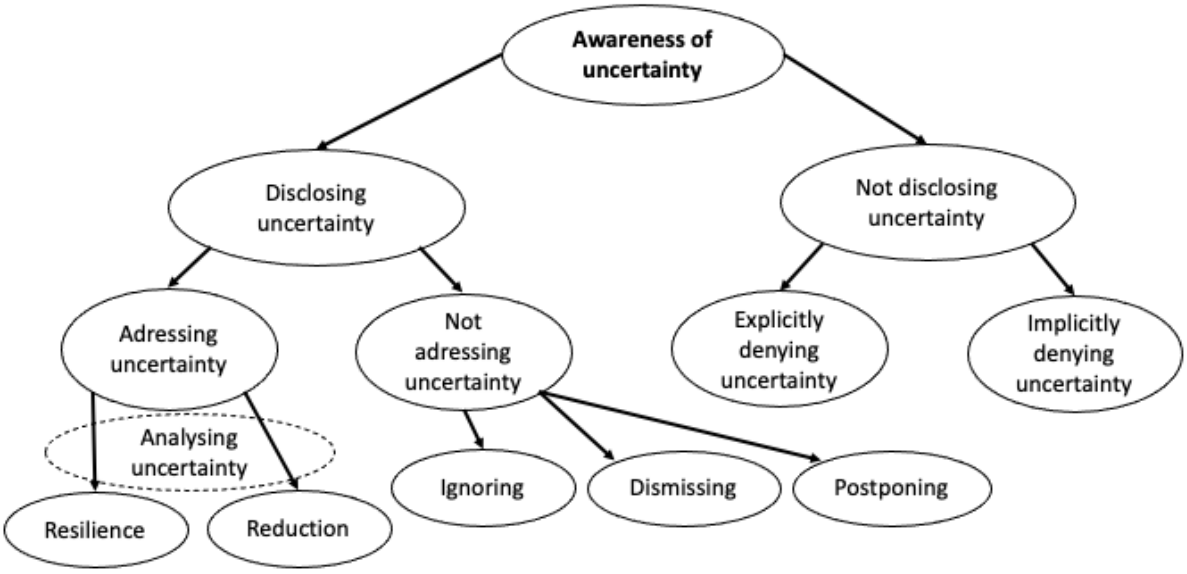

Figure 2 Some if the possible pathways when faced with uncertainty in EIA practice. Partly based on (Larsen, Kørnøv and Driscoll 2013)

As Figure 2 suggests, once awareness has been raised, uncertainty can either be disclosed or not disclosed. If it is not disclosed, this can be either by explicitly denying that there is uncertainty or by implicitly denying that uncertainty, for example by simply not mentioning it. If uncertainty is disclosed, it can be addressed, for example through formal analyses, or more actively through a strategy of reducing uncertainty or creating resilience. If uncertainty on the other hand is not addressed, it can be either ignored meaning that it is simply not mentioned again, it can be

explicitly dismissed e.g., as exemplified in Lees et al. (2016, p. 2035) by stating that that there is no need to address uncertainty because of "*the abundance and resilience of the affected component, or the small size or footprint of the project*". Finally, not handling uncertainty can take the form of postponing dealing with the uncertain issue to a later time.

Another issue concerning actors and dealing with uncertainty is how decision-makers act when faced with uncertainty in information meant to support their decision-making process. One strategy is to focus on attaining more knowledge (Adger et al. 2009; Briesbroek et al. 2009), despite the fact that Briesbroek et al. (2009, p. 232) argue that improved knowledge usually does not lead to improved decisions but instead to a need for further knowledge. According to Thissen and Agusdinata (2008), inaction is another strategy decision-makers can follow when faced with uncertainty in decision-making. Zehr (2000, p. 87) echo this in their comment on the fact that uncertainty whether substantiated or constructed can be used as an argument for lack of action: "*The science is uncertain so we better wait (sic)*".

Relevant for both decision-makers and public actors involved in the decision-making process is that the lack of disclosure and analysis of uncertainty means that the EIA and its results appear more certain than they actually are (see e.g. Tennøy, Kværner and Gjerstad 2006; Duncan 2008). As concluded by Tennøy, Kværner and Gjerstad (2006, p. 52) "*…EIA predictions are uncertain, but that decision-makers are not made aware of the prediction uncertainty. EIA predictions thus appear more certain that they are.*" This situation means that the decisions made might not be the most expedient because the basis is not fully disclosed (Tennøy, Kværner and Gjerstad 2006). As part of this, the right measures might not be set in place, for example follow-up in the form of monitoring and contingency plans (Duncan 2008). Lacking disclosure of uncertainty generally means that the stakeholders do not have the full basis for their discussions concerning the project under assessment (Tennøy, Kværner and Gjerstad 2006). This can be viewed as a democratic problem, and challenges the aim of IA, as formulated by IAIA to provide transparency and information for decision-makers and the public (IAIA 2009). In turn, this might damage the stakeholders' view of EIA, as suggested by Tennøy, Kværner and Gjerstad (2006, p. 54) "*EIAs may lose credibility among decision-makers and the public*".

In practice, Wardekker et al. (2008) find, in their study on the behavior of environmental decision-makers at the policy level, that they express an interest in receiving information about various types of uncertainty. In contrast to this, Lees et al. (2016) in a review of Canadian cases found no indications that decision-makers ask for additional information concerning uncertainty. Likewise, Larsen (2021) find that uncertainty was not an issue raised by any of the actors in hearing processes.

5. Closing remarks

This chapter has shown that uncertainty has been, to a low degree, explicitly disclosed and addressed in EIA practice. Given the importance of uncertainty awareness and transparency in decision-making, one could argue that disclosing and addressing uncertainty in EIA should be a priority for practitioners and policy-makers. However, in line with the aim of keeping the EIA focussed, as stated in the introduction, the challenge perhaps is not to analyse and address every possible uncertainty – however large and small. Instead attention should be paid to significant

uncertainties and those related to significant impacts. As with many other issues in IA, it leaves a discretion for the EIA practitioners for when and how to deal with uncertainty.

In the previous sections, a problem concerning a lack of typologies and common language is identified. This is also emphasised by other authors, such as Lees et al. (2016, p. 2038), who argue that "*…we suggest there is a need for improved understanding of, consistency among, and transparency of uncertainty reporting practices among those involved in the EA process*", as well as by Walker et al. (2003, p. 5), who state that "*There is little appreciation for the fact that there are many different dimensions of uncertainty, and there is a lack of understanding about their different characteristics, relative magnitudes and available means of dealing with them. Even within the different fields of decision support….there is neither a commonly shared terminology nor agreement on a generic typology of uncertainties….Defining uncertainty through a typology will also provide for better communication among policy analysts, policy makers and stakeholders*".

This points to an important task for research and practice, in defining and implementing typologies. Part of this might be exploring how different actors understand uncertainty, how they understand the different terms used in relation to uncertainty, and what their needs are for information on uncertainty. Another possible avenue for development in research and practice is improving our understanding of what the presence of uncertainty means for those involved in the decision-making processes. One specific focus could be what mechanisms are in play concerning whether and how uncertainty is adressed by EIA practitioners. Further exploration of such issues may provide the basis for improving the incorporation of uncertainty into EIA, mending the lacking, implicit and inconsistent incorporation of uncertainty in practice today.

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