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Article

Perspectives from 2037 – Can Environmental Impact Assessment Be the Solution for an Early Consideration of Climate Change Related Impacts?

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Abstract: Consideration of climate change in Environmental Impact Assessment (EIA) is a rather novel topic, which became partly mandatory through the revised EU Directive on EIA. Through a mixed-methods approach involving key-actors from EIA practice, decision making and climate adaptation planning, this study presents a transdisciplinary point of view on barriers and opportunities to tackle climate change adaptation in environmental assessment of large-scale projects. It is based on both a retrospective ex-post evaluation of existing practices in Austria and Germany as well as prescriptive examination and development of outcomes for practice through the development of a climate-fit toolkit that supports the incorporation of climate change impacts into EIAs. The scenario analysis applied with a back casting approach provided the opportunity to look beyond limitations related to legal compliance and partly lack of data identified by previous research. Three scenario narratives were elaborated based on nine key impact factors based on literature review, content analysis of EIA documents and interviews with EIA actors. The groups of actors carried out a prioritization of actions towards consideration of climate change in EIA. Finally, the actors were involved in co-production of an online tool-kit for Austrian and German EIA practice.

Keywords: climate change; environmental impact assessment; adaptation; scenario analysis; back casting; transdisciplinary

1. Introduction

The consideration of climate change impacts poses a serious challenge in planning, in particular for long-range infrastructure projects within fields such as energy and transport. Looking at the barriers and options through a mixed-methods approach involving key-actors from Environmental Impact Assessment (EIA) practice, decision making, and climate adaptation planning, this study enables a transdisciplinary point of view. It is based on both a retrospective ex-post evaluation of existing practices in Austria and Germany as well as prescriptive development of outcomes for practice, culminating in the creation a climate-fit toolkit that supports the incorporation of climate change impacts into EIAs.

Whereas climate proofing, namely the robustness of projects/plans to projected climate change impacts, is covered by a wide range of international and national guidance material [1–6], the awareness for early consideration of a changed project/planning environment and its likely indirect impacts on projects/ planning matter remains in its infancy. In terms of precautionary planning, many researchers have discussed the ability of Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) to address climate change impacts and adaptation [7–13]. Many of these studies identify the need to look closely at the hazards related to the changed

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susceptibility of the project environment. Recent studies [14–17] as well as guidance documents [18] highlight the importance of assessing a possible amplification of significant negative impacts on environmental issues through the plan/project.

At the European level, both climate change mitigation and risks for increased hazards/accidents due to climate change impacts need to be considered in EIA in all of the 28 EU Member States due to the revised EIA Directive (2014/52/EU), which aims at mainstreaming the awareness of climate change in project planning. Since May 2017, the Directive is mandatory for all countries. The national implementation of the content and consideration relating to climate change impacts in EIA is very diverse, however. These dissimilar outcomes might be partly influenced by the national EIA systems, lobbyism, or differing levels of awareness regarding climate change related topics among national actors in EIA (i.e. authorities, consultants, and project proponents).

A two-and-a-half-year research study (SPECIFIC) began before the implementation of EIA-Directive into national law in 2016 and followed the process through several transdisciplinary knowledge-brokerage levels [19]. In transdisciplinary (including and examining the perspective of actors from practice) and interdisciplinary (beyond one single discipline – in this context environmental planning and climate change research) knowledge transfer, one of the key challenges was to gather different actors for a balanced, open-minded, and transparent discussion process. A collection of diverse perspectives at different levels of knowledge-brokerage [20 and 21] can help to create a space which fosters new knowledge that is easily comprehensible and of use to the target groups [22–25]. A major aim of the research project was to overcome the science-policy-practice-divide [26–28] in mainstreaming climate change into EIA. The mixed-methods approach and in particular the backcasting scenario building process helped to tackle barriers – such as lack of data, specifications, guidance and legal frameworks as well as capacity and awareness of actors – identified previously by earlier studies [29–32] and allow actors with different knowledge of climate change impacts and their relevance for impact assessment to participate actively in the discourses.

This paper discusses both the transdisciplinary process – focusing on the backcasting approach in scenario analysis – and the interdisciplinary findings for EIA and SEA practice. In the following sections, the empirical results of the study are presented, guided by three guiding research questions:

- How can knowledge transfer between science and practitioners, namely among key actors in environmental impact assessment, help to strengthen the capacity to consider climate change impacts and options for adaptation?

- Which scenarios are likely for the spatial and temporal consideration of climate change impacts on projects and their associated environments?

- What are the key uncertainties and impact factors? Which barriers exist for each of the scenarios identified together with the actors?

Section Two describes the mixed-methods research design, including the primary and secondary data sources for the study along with the analytic approach employed. Both scenario impact factors and narratives are presented as findings of the transdisciplinary process in Section Three. Implications for the consideration of climate change in EIA and likely limitations are discussed in Section Four. The final outlook and conclusion are presented in Section Five.

2. Materials and Methods

2.1 Research design

In order to identify options for the consideration of climate change at an early stage in large-scale infrastructure planning subject to EIA review, the SPECIFIC study (funded under the Austrian Climate Research Program ACRP) was conducted from 2016 to 2018 to examine the possible consideration of climate change impacts in EIA in a transdisciplinary and participatory way, bringing together key actors from private project developers, consultancies, and public EIA authorities, including experts on climate change adaptation (CCA) among the federal authorities, as well as scientific experts on climate change. Scientists from climatology as well as adaptation planning were present in all phases of the process.

In this actor-based, multi-level approach (see Figure 1) examined both the awareness as well as the procedural and thematic entry points for the consideration of climate change impacts and adaptation. The aim was to identify present and potential future entry points related to climate change as well as to illustrate the relevance of considering them in EIA of large-scale infrastructure projects.

First, thematic entry points for the consideration of CCA were identified through comprehensive analysis of recent EIA and project planning documents from Austrian and German EIA practice. Between June 2016 and March 2017, a total of 23 EIA procedures in Austria and 28 procedures in Germany pertaining to rail, road, and high-voltage/extra-high-voltage transmission lines underwent an ex post evaluation using content analysis in order to identify consideration of potential CC impacts to date (EIA reports from 2005-2015) as well as possible approaches for the future. Results of this first methodological step were presented in [16] in detail.

In a second step, together with project developers, planners, and authorities, specific thematic as well as procedural entry points were discussed, first individually, in twenty expert-interviews, and then jointly in the application of a backcasting scenario analysis approach in two stakeholder workshops. Finally, an online tool-kit was developed for the target groups mentioned above in this co-design process.

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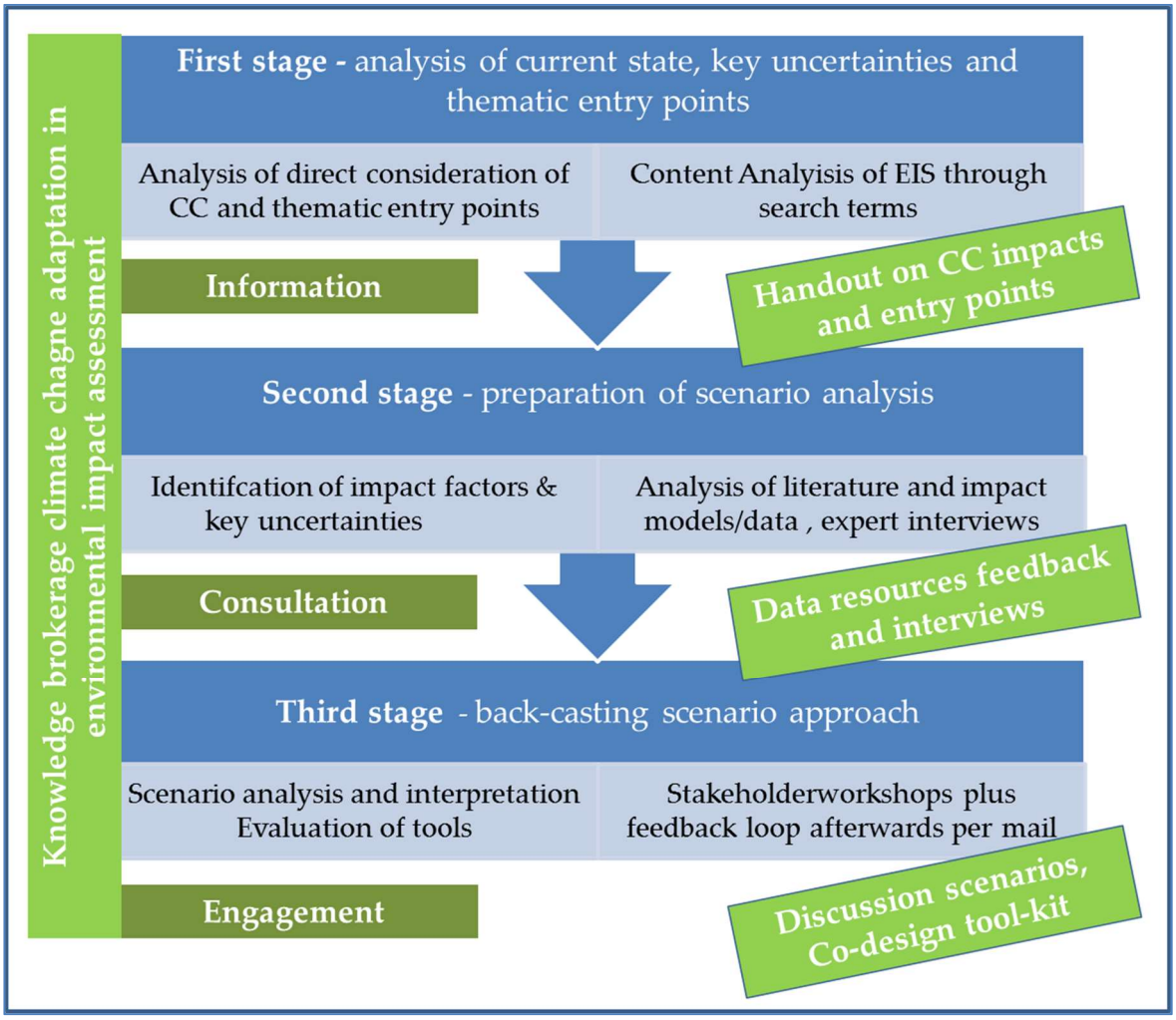

Figure 1. Multi-method approach including knowledge-brokerage levels (adapted from [19 and 33])

2.2. Preparation phase – identifying key impact factors

2.2.1 Expert interviews

Twenty expert interviews were conducted with seven EIA authorities, four project applicants and eight planning offices/ technical report authors in Austria and Germany between March and May 2017 in preparation for the stakeholder workshops. Expert sampling methods were used to identify interviewees who were selected according to the following criteria: 1) their experience with EIA practice over the past ten years; 2) the range of their expertise; and 3) their seniority (leading consultants/ heads of department). Other interviewees were included based upon specialised experience in assessment of environmental impacts. Since there were multiple people present at many of the interviews, the total number of interviewees was 34.

Interviews were structured and the interview guideline comprised three thematic blocks:

- Personal and institutional area of responsibility;

- Experience with CCA; and

- Evaluation of future development

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Wherever possible, the interviews were conducted in person, or by telephone if necessary. All interviews were transcribed, documented, and submitted to the interviewees for verification. Upon receipt of any eventual corrections, the interviews were coded, combined by similarity, and evaluated according to analytic categories that were developed using a grounded theory approach. A combination of literature review and expert interview results led to the identification of three key impact factors detailed in the following sub-section.

2.2.2 Key impact factors

In developing the narrative and analytic framework for the backcasting scenarios, three key impact factors and their interrelationships that influence the consideration of climate change in EIA were identified through a literature review evaluating the current state-of-the-art and expert interviews.

Overall key impact factors (see Table 1) for the consideration of climate change in EIA could be attributed to one of the three dimensions:

- **Framing conditions** including legislation at national and international level, guidance, specific regulations, standards, and procedural and methodological provisions;

- **Data and information t**hat require field-specific expertise of climate change impacts and options for adaptation such as climate change scenarios, impact models, and downscaling at multiple spatial levels; and

- **Capacities of relevant actors** including their know-how about climate change impacts, their values, and responsibilities.

Table 1. Impact factors influencing the consideration of CCA in EIA**.**

Key impact factors	Description
Framing conditions	
Regulations and standards (procedural consideration)	EU EIA Directive, national EIA regulations, climate change policies, domain-specific regulations including thresholds and standards
Guidance - official support complementing the legal provisions	Standards, guidelines, tools for the consideration of climate change in EIA including methodological approaches
Prior planning - Higher-level information:	Strategic Environmental Assessment, regional and sectoral plans
Data and information	
Information on Climate change	Information and data about climate change impacts at regional and local levels, including scenarios and projections
Information on Climate Proofing	Information about likely impacts on the project, in particular the increased likelihood of accidents, and options for climate-proofing
Environment/environmental issues	Information about changing susceptibility of the project environment/ environmental issues Information on efficiency of mitigation measures under influence of climate change
Capacities of relevant actors	

Key impact factors	Description
Role	Responsibilties, duties and resources
Know-how	Knowledge of climate change impacts and training
Values	Awareness, appreciation, and strategies

Once the key impact factors were identified, the research team analysed their inter-relationships. A follow-up discussion with the Advisory Board then transposed the key impact factors into distinct backcasting scenarios. These narratives for the configuration of influencing factors in different scenarios formed the framework for the backcasting scenario analysis conducted in the stakeholder workshops. Three narratives were elaborated, one of which was used as baseline for the backcasting approach:

- **"Lack of information and data" (Minimum Scenario, weak policy support);**
- **"Consideration of climate change" (Moderate scenario, some policy support); and**
- **"Detailed precautionary consideration of climate change" (Optimum scenario, high policy support)**

On this basis, guiding questions were formulated for the stakeholder workshops regarding the operationalisation for EIA might work. The main goals were: 1) to identify the existing obstacles and barriers to a comprehensive consideration of CCA in EIA; 2) to formulate suggestions for the second stakeholder workshop to enable better implementation; and 3) to evaluate a toolkit (uvpklimafit.boku.ac.at) to facilitate the consideration of climate change in practice.

2.3 Backcasting approach and scenario analysis

Advantages of a back casting approach have been described by, among others, [34–38] but also the combination with exploratory scenario approaches was highlighted by recent studies in context of climate change adaptation [39–41].

Previous papers on the barriers for the consideration of climate change in impact assessment have highlighted the conflict between uncertainties on the one hand and a regulatory and standards-based process on the other hand. In order to overcome the limiting perspective of today's framing conditions, limited knowledge, and insufficient data of spatially referenced impacts suitable for EIA purposes, a time perspective of twenty years in the future was chosen for the backcasting exercise.

Before starting the backcasting perspective, participants were informed of the current state of the art of potential climate change impacts in 2017, which were only rudimentarily incorporated in EIA in Austria and Germany. Two concrete examples based on projections of heavy rainfall and aridity for Austrian regions illustrated the extent to which such climate change-relevant aspects may already be prevalent in 2017.

Based on this introductory phase, the moderator introduced the backcasting approach, which is summarized in the following key points:

In 2037, the changes in these meteorological phenomena have already become reality. The frequency of small-scale heavy rainfall events strongly increased leading to local flash floods, heavy wind gusts, hail storms and lightning strikes. Arid periods last significantly longer on average in summer than they did ten years ago. Vegetation period in spring starts one week earlier and leads to reduced soil water content during summer. The

number of heat waves increased and maximum temperatures exceeds 40 °C frequently. Glaciers have retreated rapidly and large areas of the permafrost beyond 3000 m elevation melted.

Actors were transferred mentally in the year 2037. What has happened in EIA practice in the meantime? The narrative for a best-case target-scenario (optimum) was introduced which was characterized through the following key conditions:

- *The impacts of climate change are plain to see and are receiving high political priority.*
- *The requirements of the EIA law of 2017 (AT, DE) regarding climate change have been implemented ambitiously for the past twenty years.*
- *A wide range of auxiliary resources exists as support for the complexities encountered in practice (guidelines, scenarios, spatial data, models of effect, etc.).*
- *In consequence, risks and potential dangers for projects and environmental issues through climate change impacts are comprehensively considered in EIA.*

Participants were separated in three working groups in order to discuss by means of concrete examples of three types of large-scale infrastructure projects (railway, motorway, and high voltage power). In three sequences they discussed in the first round of the workshop the following overarching topics:

Sequence 1 Framing conditions – *"We gain background knowledge (including information, standards and objectives) on climate change adaptation for the EIA in a practice-oriented manner from higher-level planning (e.g. regional planning, SEA)"*

Sequence 2 Data and Information I – *"We can assess the climate-sensitivity of environmental issues by applying the developed models of the future situation" (humans-environmental hazards; soil-water; animals-plants-habitats)*

Sequence 3 Data and Information II – *"We optimised prevention and compensation measures with regard to climate change"*

Capacities of relevant actors were surveyed in all three sequences. In each workgroup all groups of actors were represented. Their answers were partly noted with different colours for each group in order to be able to differentiate them.

Participants were asked to report about the implementation from the backcasting perspective (twenty years ahead): *What did you do in Austria/Germany to consider potential climate change impact? What obstacles and difficulties were encountered during the process? Which information and supportive resources could be provided for the purpose of a minimum standard? Which information and resources required the greatest effort to acquire? For which steps of the EIA did this provide the greatest benefits?*

In the supplementary materials, additional guiding questions for the central impact factors were developed that supported the process and were designed to stimulate further participant reflection during the backcasting exercise (see Supplementary Material).

After this first brainstorming session, the stakeholders ranked their results according to the time-span to answer the key questions *"What exists in 2037 and what exists in 2017?"* and *"What was elaborated/ adopted after 2017 and who contributed what (responsibilities)? "* using the KETSO tool (www.ketso.com) to structure the information.

In the light of the above, scenario narratives were elaborated by the research team based on the discussion with key actor groups during the first workshop. In a second step, priority aspects for the implementation of CCA in EIA were identified and evaluated by the actors.

At the second workshop in November 2017, concrete timely actions and barriers as well as examples of tools for achieving the desired consideration of climate change were evaluated and discussed. Questions as input for the discussion were:

Which supportive resources (databases and guidelines) do you know and use so far? Are these resources sufficient to consider the potential climate change impacts? If not, which information should such supportive resources still contain? How should supportive material ideally be structured in this respect, and what are the core contents required?

Further, the applicability of data (e.g. impact models, maps, and decision support systems) with relevance to the environmental issues was discussed thoroughly, based on concrete examples. During this process, the overview of existing data evolved from the aforementioned initial analysis of all research projects funded under the Austrian CC research programs (e.g. ACRP) and the consultation of federal authorities in the field.

Following the stakeholder workshops the factors' interrelations were analysed again. A follow-up discussion with the Advisory Board after the first workshop then sought to discuss barriers as well as options to facilitate the enhancement of the scenarios. Both workshops, which were attended largely by the same participants, built upon each other structurally.

2.4 Description of the sample – stakeholders involved in the study

Finally, altogether nine EIA consultants from Austria and Germany and seven Federal EIA Authorities as well as four project developers and one Climate Service Centre expert were involved in the entire process. For each workshop about two to three additional participants joined from additional members of the three categories of actors.

Photo 1. First stakeholder workshop in June 2017 large group discussion (left),

Photo 2. First stakeholder workshop in June 2017 results from the KETSO sequence (right)

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Photos 3 and 4. Second stakeholder workshop in November 2017

The acting knowledge brokers in this process were the Environment Agency Austria, the Ministry of the Environment as well as universities specialised in planning and impact assessment as well as CCA research (such as BOKU Vienna). Additionally, some of the actors involved in EIA could also be considered as knowledge brokers in the process (see [19]), such as EIA consultants in planning offices as well as the specific environmental authorities involved in the process of scoping and issuing environmental statements, which communicate the relevance of topics to be considered in EIA to the project developer.

3. Results

3.1. *Expert interviews*

The interviews showed several differences between the groups of actors. Project applicants and proponents, in particular, already understood the relevance of considering climate change in their technical planning and in their ongoing operations. They saw no relevance, however, of gaining information about these topics from EIA, or of addressing them in EIA. Some Austrian authorities considered climate proofing to be within the project applicants' and proponents' own responsibility, and disconnected from EIA. German authorities, on the other hand, emphasized the potential to be gained from an interaction between the examination of environmental issues in EIA and the technical project planning, regarding climate proofing. Through the "one-stop-shop" principle natural hazards were already part of the EIA in Austria (e.g. geology, soil, water). However, future influence of climate change was not yet considered and would be a novelty for both countries. Table 2 summarizes the results of the interviews relevant for the impact factors subject to the scenario analysis.

Table 2. Summary of the analysis of expert interviews.

Key impact factors	Summary of core content
Framing conditions	
Regulations and standards (procedural consideration)	• Lack of legal specification by authorities; and • Major challenge: Combination of the uncertainty of climate scenarios with the strict legal obligations of the EIA (one-stop-shop commissioning procedure in Austria).
Guidance - official support complementing the legal provisions	• Lack of support for EIA at national level; • integration of climate change related aspects in guideline of the Environment Agency Austria recommended.
Prior planning - Higher-level information:	• Rare consideration of climate change in Strategic Environmental Assessment; and

Key impact factors	Summary of core content
	• Support of superior levels (e.g. regional and sectoral plans) highly important to address general impacts and identify alternatives.
Data and information	
Information on Climate change	• Availability of impact models relevant for direct application in EIA is limited; • Lack of knowledge on available data (in particular EIA consultants); and • The importance of integrating uncertainties and risks in the context of future projections must be emphasized.
Information on Climate Proofing	• Partial integration of climate proofing (project developers themselves); and • Natural hazards management could be a key factor to establish CC adaptation in EIA.
Environment/environmental issues	• Natural hazards related topics; status quo is considered as enough in most cases; • Relevance for CC impacts on flora/fauna/biodiversity not yet recognized in practice; and • Rarely consideration of climate change when developing mitigation measures to minimize/compensate environmental impacts.
Capacities of relevant actors	
Role	• Differences between the groups in providing data/standards and thematic consideration (climate proofing and/or environmental changes)
Know-how	• Partly lack of awareness for climate change-related aspects; and • Need for capacity building to consider specific environmental impacts due to climate change. • Confusion of adaptation with climate mitigation happens frequently.
Values	• Differences partly visible between Austrian and German actors

3.2 Narratives for three scenarios on the consideration of climate change in EIA

The role of the impact factors presented in Section 2.2 as well as their changes from the backcasting perspective of 2037 were discussed throughout the stakeholder workshops. Three narratives were developed before the workshops and adapted/ amended afterwards in order to reflect the diversity in the performance of the key factors. Table 3 illustrates in detail the differences regarding key impact factors for "framing conditions" and "data and information" in the narratives. The diverse

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attitude of the actors ("capacities and relevant actors") towards the three narratives are analysed subsequently in Section 3.3.

3.2.1 "Lack of information and data" (Minimum Scenario, weak policy support)

Overall a lack of data in order to describe the likely development of the sensitivity of the environmental issues and to assess likely impacts on the project and its environment were a central concern of the EIA actors. In particular, missing integration of climate change-related impacts into standards and domain-specific guidance was identified as a core uncertainty in an EIA regime driven by commissioning procedures. Despite these challenges, a qualitative approach was discussed in order to integrate climate change adaptation as far as possible and consider it in particular when assessing environments which are highly sensitive to climatic conditions (and changes) such as higher alpine areas, wetlands, or areas prone to flooding. In this scenario, the identification of adaptation potential in mitigation measures subject to both the construction and the operation phases of projects subject to EIA as well as the monitoring phase afterwards were in focus.

According to the workshop participants, supportive resources (e.g. fact sheets) with general specifications regarding qualitative estimation of the possible consequences of climate change impacts, as well as regarding consideration in EIA and climate proofing, are available. Spatially referenced information integrating climate scenarios is not available; nor do they contain concrete models of climate change impacts on the potential environmental issues. The guidance documents do not contain specific information on the development of adaptation measures for climate proofing that reflect locational factors nor do they address specific climate change adaptation as topic of mitigation and compensation measures subject to EIA.

3.2.2 "Consideration of climate change" (Moderate scenario, some policy support)

In contrast to the narrative presented above, the moderate scenario targets a consideration of climate change and options for adaptation based on scientific findings regarding climate change impacts. In particular, a complete description of the likely influence of climate change on environmental issues in the zero variant (climate-change affected baseline) enables the consideration of the changed sensitivity in the assessment of impacts. Studies are referred to during classification of the potential impact on environmental issues that are related to the expected change of the selected climate parameters and incorporated in the procedural steps of the EIA in case significant impacts on the environmental issues and project are likely to occur. Whereas information is available from superior levels about planning goals and challenges in CCA (e.g. from Federal adaptation strategies or spatial planning concepts at federal state level), no spatially referenced data is offered from guidance. Guidance documents (e.g. guidelines) with specifications regarding the consideration of climate change impacts in EIA as well as regarding climate proofing, are available. They contain information regarding altered meteorological parameters and associated potential climate change impacts, or concrete examples of effects regarding the environmental issues potentially affected. Project-specific information on climate proofing topics is available, considering indirect impacts through a changed project environment (amplified risk for hazards and accidents). The guidance documents contain information about alternation of mitigation and compensation measures in EIA in light of climate change adaptation for all environmental issues.

3.2.3 "Detailed precautionary consideration of climate change scenario" (Optimum scenario, high policy support)

In order to fulfil the precautionary principle and consider both the project's resilience and the sensitivity of the environmental issues under changing climatic conditions, spatially referenced

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information is essential and allows a concrete integration of the emerging or exacerbated aspects, particularly over the long life-span of road, rail, and energy transmission projects. Adaptation in mitigation measures and compensation is accompanied by an adaptive monitoring. The EIA already identifies critical mitigation and/or compensation targets and determines the necessity when and how to monitor them.

Supportive resources and guidance (database, online-tools, and guidelines) with specifications regarding consideration of climate change impacts in EIA as well as regarding climate proofing, are available. They contain spatially referenced data about likely climate change impacts, or concrete impact models applicable for the assessment of the environmental issues potentially affected. Project-specific information on climate proofing is available, with reference to topography and climatic conditions at regional/local level. The guidance documents contain information linked to climate change signals/stressors relevant for the development of mitigation and compensation measures in EIA which help to consider and minimize climate change impacts for all environmental issues likely to be affected as well as about climate proofing to adapt projects affected by indirect effects of a changed project environment.

Table 3. Comparison of differences between the three narratives for each impact factor.

Impact factors/ Scenario narratives	Lack of information and data Scenario	Consideration of climate change likelihood scenario	Detailed precautionary consideration of climate change scenario
Framing conditions			
Regulations (procedural consideration)	• Qualitative description of climate change impacts on the project and environmental issues (if relevant); and • Serve as background information for EIA.	• Central climate change impacts relevant for the climate proofing (risks and hazards) in context with the environmental issues are described and contained already in scoping and the zero-alternative; • Constitute a reference point in particular to assess environments which are highly sensitive to climatic conditions and changes; and • Mitigation and compensation	• Central climate change impacts are considered in the assessment of highly significant impacts of all environmental issues, for climate proofing (risks and hazards) as well as the assessment of augmented impacts by the project; • They are integrated in all procedural steps of the EIS; and • New mitigation and compensation measures are introduced or

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		measures are adapted if applicable.	targets revised if relevant, plus adaptive monitoring.
Guidance – official support complementing the legal provisions	• Listing overall topics for climate proofing/ changed sensitivity of environmental issues; • General recommendations for methodological consideration; and • No spatially referenced data/information.	• Project-specific information on climate proofing topics; • Augmented impacts through a changed project environment (amplified risk for hazards and accidents) are highlighted; and • Information on alternation of mitigation and compensation measures in EIA in light of climate change adaptation for all environmental issues.	• Supportive resources and guidance (database, online-tools, guidelines etc.) with specifications regarding consideration of climate change impacts in EIA as well as regarding climate proofing; • They contain spatially referenced data; and • Project-specific information on climate proofing is available, with reference to topography and climatic conditions at regional/local level.
Prior planning - Higher-level information (e.g. SEA)	• No planning goals and/or spatial statements regarding climate change impacts can be derived from higher-level planning projects or protected area regulations, or only in very few cases; and	• Planning goals and spatial statements regarding climate change impacts can be derived from higher-level planning or protected area regulations; and • However, there are no	• Planning goals and spatial statements regarding climate change impacts can be derived from higher-level planning projects; and • The examination of alternatives in the SEA has

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	• No SEA occurred or SEA did not consider climate change.	statements/data available about climate change impacts which can be directly integrated into EIA scope.	already considered levels of the mitigation hierarchy which are later on relevant when assessing project-specific climate change impacts and options to avoid/minimize them.
Data and information			
Information on climate change (projections)	• Selection of fundamental base parameters for precipitation and temperature with a high relevance for the project scope is taken into consideration at national and Federal state level; and • a mid-term period timeframe.	• Regional climate projections are available with parameters for precipitation and temperature as well as for related extreme events; and • Projections are based on diverse emissions scenarios, mid and long term time scales.	• Regional climate projections are available with parameters for precipitation and temperature as well as for related extreme events; and • Projections are based on diverse emissions scenarios, short, mid and long term time scales.
Information on impact of climate change on the environmental issues in EIA	• There are no statements available on the climate sensitivity of an environmental issue (expert recommendations, models of effect, scientific studies, etc.); and • A general qualitative estimate is made	• There is information available (expert recommendations, models of effect, scientific studies, etc.), on the climate sensitivity of environmental issues, and • However, most of the information is not regionally specific/ directly	• Scientific studies/models are available describing regional change of distribution/range for individual environmental issues; and • Maps from these studies serve as reference for classification of potential impact

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	based on the potentially influencing climate parameters and international experience and/or NAS.	applicable for the EIA area.	on environmental issues and are incorporated in the procedural steps of the EIS.

3.3 Challenges and changes to consider climate change in EIA

As the backcasting approach demonstrated, for many actors the existence of information required to apply the medium to optimum scenario seems feasible given a mid-term timeframe. Taking into account the long lifespan of many projects subject to EIA, the hesitance to apply at least a minimum scenario today at the beginning of the workshops was surprising but confirms results of previous studies on climate change in EIA [32, 42, 43].

Foresight consideration of climate change in terms of the optimum scenario was questioned by most of the actors, unless the framing conditions change substantially. Looking at the implementation of the EU Directive 2014/52/EU into national law in Germany and Austria, differences might be partly influenced by the strong involvement of the experts in charge for the legal processes in the Austrian ministry. The Austrian amendment includes the necessity to consider the risk of accidents caused by natural hazards and due to climate change also in the environmental report and if relevant in the assessment of significant environmental impacts of the project subject to EIA. In the annotation to the novel regulation the focus on resource efficiency, climate change, and risks is highlighted at the beginning. Further details for the consideration of climate change-related aspects for climate proofing are included and reference to the EU guidance [44] is made.

Nevertheless, the consideration of the changed sensitivity of the project environment is only required in context of increased likelihood of risks and accidents but not regarding the precautionary assessment of impacts to all environmental issues as suggested by international studies and guidance [15, 18, 45]. This is particularly alarming given the vast number of recent studies highlighting the likely impact of climate change on biodiversity including the risk of total extinction of species with specific habitat demands [46 and 47]. Particularly in the Austrian EIA scope (project types and environments likely to be concerned), endangered species could be affected over the long term. Therefore, the integration of these newly emerging topics into the sector/domain-specific standards and guidance is very important in order to achieve a precautionary approach. The perception of stakeholders varied in this context, however. Project proponents opted for exclusion or only very abstract consideration of these topics due to lack of standards and regulations demanding their inclusion. Authorities were only partly experienced with the topics and started capacity building only over the past few years. Consultants are in between the two groups and expressed the need to partially integrate new aspects. Since consultants not obliged to apply a medium to long-term perspective (not even in the zero variant so far) and they lack substantial information on spatially referenced impacts for the environmental issues at regional/local level, they are hesitant in introducing these topics into the complex EIA one-stop-shop commissioning process. As a primary solution to consider CCA over the medium to long-term, integration of these topics in adaptive monitoring with options to revise mitigation targets and measures were frequently proposed. Priority actions of all actors in approaching climate are summarized in Table 4 below.

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385 **Table 4.** Priorities to consider climate change in EIA – agreement of all groups of actors.

Approach/ Requirements	Impact factor adressed	Relevance/ Prioritization
Long-term Monitoring (extended monitoring period)	Information on impact of climate change on the environmental issues in EIA.	High
Publicly available climate impact models (spatially referenced and/or transferable to other areas)	Information on climate change (projections) and on impact of climate change on the environmental issues in EIA.	High
Publicly available climate projections at regional level	Information on climate change projections.	Medium
Flexible and dynamic mitigation targets and measures	Procedural consideration and Information on climate change projections and on impact of climate change on the environmental issues in EIA.	Medium
Guidance on methodological and thematic consideration of climate change impacts	Guidance – official support complementing the legal provisions.	Medium
Communication of Risks and uncertainties	Information on Climate Proofing/ capacities of actors.	Low
Land Management Concepts („Flächenpools“)	Linked to procedural consideration of climate change.	Low

386 **4. Discussion**

387 The findings clearly demonstrate that the awareness to consider potential for long-term CCA,
388 bearing in mind the long lifespan of most projects subject to EIA, is still in its infancy and faces many
389 challenges.

390 EIA is based on standards and conventions in Austria (due to the one-stop-shop principle), which
391 are only slowly integrating climate change-related aspects. All three groups of actors agreed that
392 the range of considerations of CCA in EIA practice are highly dependent on the legal framework
393 conditions and integration of related topics into standards (e.g. thresholds or lists of endangered
394 species if applicable).

395 Nevertheless, the scenario analysis applied with a backcasting approach provided the opportunity
396 to look beyond these limits related to legal compliance and partly lack of data identified by previous
397 research [14 and 17]. Overall the multi-method approach helped to illustrate the ability for
398 consideration of climate change impacts through several steps of the EIA process. Taking into
399 account vulnerability models, which are already available for specific topics for each environmental
400 issue, was specifically helpful. These concrete examples of impact models relevant for
401 environmental issues supported the backcasting approach substantially.

Whereas the majority of actors and in particularly the project developers recognized the need for climate proofing, the awareness of the aspects relevant to a likely changed impact on environmental issues was only increasing over the two workshops. Here differences between the groups of actors became evident as consultants and authorities were partly more familiar with changed sensitivities of environmental issues as well as impact models. Consultants seemed to seek orientation from competent authorities in order to propose these newly emerging topics with increasing relevance to the project proponents.

Guidance could, as for other novel topics in the past, facilitate this process but would be jointly linked to legal requirements in the actors' point of view. Among the existing guidance documents, the IEMA guideline [18] is the most detailed one regarding concrete methodological entry points and suggests also a consideration of the "sensitivity of topic-specific environmental receptors to climate change", which stresses the need to look particularly at those environmental issues "reliant on specific climate conditions" [18, p. 13]. The guideline by the European Commission [44] in contrast focuses on thematic entry points but remains at a rather abstract level of information. For SEA, the EPA guideline [45] integrates thematic and methodological support. Thereby sectoral relevant thematic aspects were illustrated and sources of information are added.

Looking at the three scenario narratives, the likely development of supportive guidance which allows a "Detailed precautionary consideration of climate change", as outlined in the "optimum narrative", is highly dependent on spatially referenced information and an interdisciplinary overview of data resources to be integrated into the impact assessment process.

As an outcome of SPECIFIC an online toolkit (uvpklimafit.boku.ac.at) was developed which contains both project specific information on likely climate change-related impacts to the project including specified information of related hazards and accidents risk and specific environmental issue information about amplified impacts and possible vulnerability alternatives [48]. Moreover, the online toolkit showcases impact models relevant for environmental issues subject to EIA available in Austria and Germany. These are partly covering the whole country, partly they are depicting likely changes for selected Federal states or regions or they comprise certain indicator species.

Through the ranking of priority actions in order to achieve the optimum narrative outlined at the beginning of the backcasting approach essential steps (and related "actions") became visible for the EIA actors. These considerations were again helpful for the creation of the online "Directory" for "climate fit EIA and project planning". Some of these actions might be specific to the Austrian system of a one-stop-shop principle commissioning process but others are relevant internationally such as adaptive monitoring approaches[49] including more flexible and dynamic measures.

The scenario analysis together with the expert interviews confirmed also certain limitations to the consideration of climate change impacts at the level of project planning pointed out by previous studies [13]. Benefits of a strategic consideration of climate change impacts at a prior level were discussed and confirm studies such as [11 and 12], which highlighted the role of SEA in considering climate change mitigation and adaptation. In particular, in context of mitigating potential conflicts plans/ programs accompanied by a SEA could gain importance to identify alternatives, which are less likely to lead to major conflicts of resources and interests. This could be particularly important also to offset the conflicts of interest related to climate change impacts, adaptation to them and mitigation, which partly can be tackled more easily at different planning levels.

5. Conclusions and Outlook

The multi-method approach with a combination of the pre-phase including the content analysis of previous EIA to find topical entry points as well as individual expert interviews followed by the

scenario analysis was suitable to discuss solutions which are particularly relevant to the Austrian and German EIA system. In both countries the impact assessment is strongly based on regulations and standards. The Austrian EIA comprises already topics related to climate change impacts, such as natural hazards prevention, due to its "one-stop-shop" principle as commissioning instrument for all specific matters. In context of climate change adaptation this bears both opportunities – as some of these topics are not novel to the authorities and EIA consultants – and challenges – due to the lack of standardized models of climate change impacts and/or specific guidance to be taken into consideration within the legally binding process. Through the backcasting approach with the elaboration of three different narratives based on nine key impact factors, identified through literature review and consultation of EIA experts, the actors could discuss key actions to consider climate change, its impacts on both projects and the environmental issues as well as adaptation pathways to it. Amongst others the awareness of the existence of climate change related impact models relevant to specific environmental issues' sensitivities was a key experience. Consequently the know-how and capacities of actors was part of the discussion as well as the responsibility for approaching these novel topics throughout the EIA process.

Whereas project developers primarily recognized their role in identifying topics for climate proofing, the leading role in considering a changed sensitivity of the environment as well as the potential benefits (e.g. for the hazard prevention and indirectly climate proofing) was discussed diversely, also among the German and Austrian experts. Feasibility was still questioned with regard to implementation of a highly precautionary narrative. However, the joint identification of key actions allowed to discuss its operability in a "twenty years a head perspective". Results of the workshops and scenario approach influenced directly the development of an online tool-kit on the consideration of climate change impacts (impacts on nine types of infrastructure projects, the environmental issues most susceptible to climate change and likely indirect effects for the fitness to climate change of the projects as well as likely augmented impacts by the projects on the environment). The integration of key findings as well as the summary of the tool-kit's purpose and content into the principle Austrian EIA guideline was envisaged and encouraged by direct involvement of key authors of the responsible institutions throughout the whole process. A change of government hampered this action, however.

This study focused on key impact factors during the elaboration of the EIA until 2037. For this purpose particularly, thematic and methodological entry points were viewed in detail. These are applicable independently from the EIA system. To what extent climate change related topics are taken into account in decision making is, however, highly dependent on the EIA system and planning/commissioning regulations. Internationally speaking the challenge remains to what extent climate change is taken into account in the final decision making process. Recent studies report a very low consideration in the final step of the EIA procedure [50 and 51]. Next to regulations, particularly the perspective of actors and their awareness of relevance of an early consideration of climate change in EIA might be highly relevant in this context as well as their capacities and roles in the process.

Supplementary Materials: The following are available online at www.mdpi.com/xxx/s1, Figure S1: title, Table S1: title, Video S1: title.

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637 # Supplementary Material

638 **Table 1.** Guiding questions to determine the differentiation of the impact factors from the optimum
639 to the minimum scenario.

Key impact factors	Description
Framing conditions	
Guiding questions Stakeholder process factor "Prior planning - Higher-level information:"	Which plans/programs/strategies serve as a source of information, containing objectives, information, and measures that target the incorporation of climate change adaptation in EIA?
Supportive questions for the stakeholder process factor "Prior planning - Higher-level information:"	Is tiering possible between SEA and EIA regarding the consideration of climate change adaptation and if so, for which sectors/types of projects? Do you know benefits and limitations based on personal experience of tiering between SEA and EIA?
Guiding questions Stakeholder process factor "Guidance - official support complementing the legal provisions"	Which support is available to consider climate change impacts in EIA and project planning? Which support would be necessary to consider climate change impacts in EIA and project planning?
Supportive questions for the stakeholder process "Guidance - official support complementing the legal provisions"	Which format is most suitable? Which topics should be covered? What is the appropriate level of detail/ amount of information to be covered?
Guiding questions Stakeholder process factor "Procedural consideration"	How should EIA consider climate change impacts during the methodological approach and procedural steps?
Supportive questions for the stakeholder process factor "Procedural consideration"	Which steps of the EIS/EIA are central for the integration of climate change in your point of view? How should information to describe the environment in the case of non-implementation of the project (zero alternative) be deduced? How far can EIA consider climate change impacts during the assessment of significant environmental impacts and/or during the application of the mitigation hierarchy? Can an early climate change impact check during scoping facilitate the consideration during the EIA process and avoid overshooting efforts/expenditures?
Data and information	
Guiding questions Stakeholder process factor "Information on climate change:"	Which climate data should be included in EIA?

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Key impact factors	Description
Supportive questions for the stakeholder process factor "Information on climate change"	Which meteorological parameters are suitable standards from which to draw conclusions about the impact on environmental issues in the EIA? Which timeframes and scales for climate parameters make sense in EIA and should be standardised? How should EIA practitioners deal with the range and uncertainty in the climate projections (scenarios)?
Guiding questions Stakeholder process factor "Information regarding the impact of climate change on the environmental issues in EIA"	How can EIA integrate prognoses on susceptibility or climate sensitivity of environmental issues (regarding the two example climate change impacts) – at which stages in the process is which information necessary (e.g. presentation of the current status, zero alternative or assessment of environmental impacts)?
Supportive questions for the stakeholder process "Information regarding the impact of climate change on the environmental issues in EIA"	How can the sensitivity of environmental issues to climate change be ascertained? How far can EIA consider changing conditions, which some plant and animal species might encounter due to adverse future conditions and which may be condemned to local extinction? Which information is missing in this regard – based on the status-quo of consideration in the procedural steps of the EIA? How can mitigation and compensation measures be planned in a way that they will also maintain their functionality under uncertain climate change conditions? How can such measures be monitored to guarantee their functionality?
Capacities of relevant actors	
Guiding question "Role & Know-how"?	Which information is the project applicant required to provide, and which information ought the relevant authorities provide (feasibility among the actors)?
Guiding question "Values"?	What influence does your or your business' personal or institutional set of values have on your classification of scenarios and on your answers to the questions thus far? What could change in this respect, what is realistic, what would be necessary?

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