Legitimate Knowledge Policy Co-Production towards Just Climate Action

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Summary

Climate change is one of the most pressing challenges of our time, with far-reaching consequences for human societies and natural ecosystems. Its impacts disproportionately affect those who have contributed the least to greenhouse gas emissions, making it a profound challenge of justice. To address this complex and multifaceted issue, policymaking needs to be informed by knowledge. Despite the critical role of science-policy interfaces (SPIs), institutions connecting knowledge and policymaking, in addressing climate change, existing approaches often fail to effectively integrate diverse knowledge systems and meaningfully engage stakeholders. Based on four publications, this dissertation explores how SPIs can be enhanced to foster more effective and just climate actions.

To establish a foundation for this exploration, following the introductory chapter, the second chapter systematically reviews the existing literature on SPIs in the realm of environmental sustainability. It identifies key types of SPIs, their outputs, and their impacts on policymaking. The findings demonstrate that SPIs significantly influence policy formulation and agenda-setting. The chapter highlights factors contributing to SPI effectiveness, including stakeholder participation, interdisciplinarity, diverse expert backgrounds, and effective communication of complex knowledge. By emphasising the importance of effectiveness as outlined in the literature, this chapter sets the stage for examining how legitimacy can further strengthen SPIs' capacity to advance more just climate actions.

Building on the insights from the systematic review, the third chapter advocates a novel shift from SPI effectiveness to legitimacy as a pathway for fostering just climate actions. Integrating the literature on SPIs with the scholarship on legitimacy through an integrative literature review provides the main theoretical contribution of the dissertation. Recognising that SPIs are inherently powerful and political instead of apolitical and neutral institutions, this chapter develops a framework to evaluate the legitimacy of SPIs across three dimensions: input, throughput, and output. Input legitimacy emphasises inclusivity, transdisciplinarity, and the integration of diverse knowledge systems to ensure that multiple perspectives inform knowledge production. Throughput legitimacy focuses on procedural elements like transparency, reflexivity, and accountability to ensure fairness and accessibility. Output legitimacy assesses the efficacy, understandability, and dissemination of SPI outputs to ensure their relevance and impact. By advancing this framework, this chapter underscores how legitimacy can enhance SPIs' role in addressing the justice challenges posed by climate change.

The fourth chapter applies the legitimacy framework to analyse how local SPIs can be enhanced to foster just climate actions. Examining the development of urban climate action plans (UCAPs) in Accra (Ghana), Bonn (Germany), São Paulo (Brazil), and Ahmedabad (India), based on 73 semi-structured interviews and document analysis, this chapter provides comparative insights into how UCAPs are created and the extent to which different criteria of legitimacy are fulfilled. It highlights

the critical role of city network organisations in supporting and funding UCAP processes. The chapter reveals significant differences across the cases in terms of co-production, transparency, and participation. These variations demonstrate how fostering co-productive, inclusive, and transparent processes can bridge knowledge gaps and enable legitimate, just urban climate actions.

Expanding the analytical lens from the local to the global scale, the fifth chapter analyses the IPCC to identify pathways for enhancing its role in fostering just climate actions. Through qualitative analysis of 46 interviews with IPCC scientists and policymakers, this chapter reveals how modernist logics, framing the IPCC as an apolitical and universal source of knowledge, shape its operations. However, it also identifies emerging efforts to unlearn these constraints by broadening disciplinary diversity, incorporating diverse epistemologies such as Indigenous knowledge, and fostering co-productive collaborations between scientists and policymakers. These shifts indicate potential pathways for enhancing the IPCC's legitimacy, aligning it more closely with principles of justice and inclusivity in climate action.

Synthesising the findings from these chapters, the dissertation argues that Legitimate Knowledge-Policy Co-Production (LKPC) provides a novel framework for combining co-production with legitimacy principles, distinguishing itself from approaches primarily built on effectiveness and an apolitical, policy-neutral understanding of SPIs. By integrating diverse knowledge systems - including interdisciplinary, local, and Indigenous perspectives - LKPC enhances the epistemic quality of SPIs, ensuring more comprehensive and contextually relevant understandings of climate actions. Simultaneously, it strengthens participatory quality by fostering transparent, inclusive, and accessible processes that bridge the gap between scientific expertise and meaningful stakeholder engagement. Based on the empirical insights from the four UCAP creation processes and the research on the IPCC, it is argued that LKPC contributes to enabling the effectiveness of climate actions - tailored to specific contexts with a greater likelihood of implementation - and justice, addressing the needs of those most vulnerable to climate change impacts.

This dissertation's overarching contribution lies in its development of LKPC for reimagining SPIs to foster just and effective climate action at different scales. Conceptually, it redefines how SPIs can integrate legitimacy and co-production to address both epistemic and participatory challenges, bridging the gap between knowledge production and policymaking. Empirically, the dissertation provides insights from local and global SPIs - namely UCAP creation processes and the IPCC - highlighting pathways to overcome barriers to inclusivity, reflexivity, and transparency. Practically, the findings offer actionable guidance for SPI stakeholders to enhance legitimate SPI co-production processes for ensuring climate actions that are contextually relevant, inclusive, and more likely to be implemented. Ultimately, this work highlights that through legitimate co-production processes bringing together knowledge and policy, SPIs can bridge the gap between knowledge and action to achieve justice-centred responses to the climate crisis.

Zusammenfassung

Der Klimawandel ist eine der drängendsten Herausforderungen unserer Zeit und hat weitreichende Konsequenzen für menschliche Gesellschaften und natürliche Ökosysteme. Seine Auswirkungen betreffen überproportional jene, die am wenigsten dazu beigetragen haben, was ihn zu einer fundamentalen Frage der Gerechtigkeit macht. Die Bewältigung dieser Gerechtigkeitsproblematik erfordert die Integration von Wissen in politische Entscheidungsprozesse. Trotz der zentralen Rolle von Institutionen, welche Wissen und Politik zusammenbringen (*Science-Policy Interfaces,* SPIs), bei der Bekämpfung des Klimawandels, scheitern bestehende SPI Ansätze häufig daran, unterschiedliche Wissenssysteme effektiv zu integrieren und relevante Akteure angemessen einzubinden. Basierend auf vier Publikationen untersucht diese kumulative Dissertation wie SPIs verbessert werden können, um wirksamere und gerechtere Klimamaßnahmen zu fördern.

Im Anschluss an die Einleitung bietet das zweite Kapitel der Dissertation einen systematischen Literaturüberblick zu SPIs und deren Wirkung auf politische Entscheidungsprozesse, der als Fundament für die weitere Untersuchung dient. Das Kapitel identifiziert zentrale Typen von SPIs, deren Ergebnisse und deren Auswirkungen auf politische Entscheidungsprozesse. Dabei werden zentrale Erfolgsfaktoren für wirksame SPIs herausgearbeitet: die gezielte Einbindung relevanter Akteure, fachübergreifende Zusammenarbeit, die Vielfalt an Expertise sowie die erfolgreiche Vermittlung komplexer Sachverhalte. Die Analyse der Effektivitätsfaktoren bildet die Basis für die weiterführende Untersuchung der Dissertation, wie die Legitimität von SPIs dazu beitragen kann, fairere und gerechtere Klimaschutzmaßnahmen zu entwickeln.

Aufbauend auf den Erkenntnissen der systematischen Literaturübersicht wird im dritten Kapitel ein Ansatz entwickelt, welcher den Fokus von der Effektivität hin zur Legitimität von SPIs verschiebt, um gerechte Klimamaßnahmen zu unterstützen. Durch die Verknüpfung der SPI-Literatur mit der Legitimitätsforschung liefert der in diesem Kapitel entwickelte theoretische Rahmen den zentralen theoretischen Beitrag der Dissertation. In Anerkennung der Tatsache, dass SPIs inhärent machtvoll und nicht politikneutral sind, entwickelt das Kapitel ein Rahmenwerk zur Bewertung der Legitimität von SPIs entlang dreier Dimensionen: Input-, Throughput- und Output-Legitimität. Diese theoretische Weiterentwicklung zeigt auf, wie erhöhte Legitimität dazu beitragen kann, dass SPIs Gerechtigkeitsaspekte des Klimawandels wirksamer adressieren.

Im vierten Kapitel wird der entwickelte Legitimitätsrahmen auf lokaler Ebene angewandt, um Verbesserungspotenziale für gerechte Klimaschutzmaßnahmen zu identifizieren. Die Untersuchung konzentriert sich dabei auf die Entwicklung städtischer Klimaschutzpläne in vier Städten: Accra (Ghana), Bonn (Deutschland), São Paulo (Brasilien) und Ahmedabad (Indien). Auf Basis von 73 semistrukturierten Interviews und umfassenden Dokumentenanalysen wird verglichen, wie diese Pläne entstehen und welche Legitimitätskriterien dabei in welchem Maße erfüllt werden. Die Analyse unterstreicht dabei die Schlüsselrolle städtischer Netzwerke für die Unterstützung und Finanzierung der Planungsprozesse. Zwischen den untersuchten Städten zeigen sich deutliche Unterschiede hinsichtlich der gemeinsamen Wissensentwicklung, der Transparenz und der Beteiligung verschiedener Akteure. Diese Unterschiede

machen deutlich, dass partizipative, inklusive und transparente Prozesse nicht nur Wissenslücken schließen, sondern auch zu legitimeren und gerechteren städtischen Klimaschutzmaßnahmen führen können.

Indem die analytische Perspektive vom Lokalen um die globale Ebene erweitert wird, analysiert die Dissertation anschließend den Weltklimarat IPCC, um Wege aufzuzeigen, wie dessen Rolle bei der Förderung gerechter Klimamaßnahmen verbessert werden kann. Durch qualitative Analysen von 46 Interviews mit IPCC-Wissenschaftler*innen und politischen Entscheidungsträger*innen zeigt das Kapitel wie die Modernität, die den IPCC als apolitische und universelle Wissensquelle rahmt, dessen Arbeitsweise prägen. Gleichzeitig zeigt die Analyse neue Ansätze auf, wie diese Einschränkungen überwunden werden können, u.a. durch größere Vielfalt in der Zusammensetzung der Akteur*innen, die Einbindung alternativer Wissensformen wie indigenes Wissen und die Förderung einer engeren Zusammenarbeit zwischen Wissenschaft und Politik. Die in diesem Kapitel beschriebenen Entwicklungen weisen Wege auf, wie der IPCC seine Legitimität stärken und sich konsequenter an den Prinzipien der Gerechtigkeit und Inklusivität orientieren kann.

Die Zusammenführung der Ergebnisse aus allen vier Kapiteln führt zum Konzept der 'Legitimen Wissens-Politik-Koproduktion' (*Legitimate Knowledge-Policy Co-Production*, LKPC). Dieser Ansatz verbindet Koproduktion mit Legitimitätsprinzipien und unterscheidet sich damit grundlegend von bisherigen Konzepten, die vor allem auf Effektivität und einer vermeintlich neutralen und apolitischen Rolle von SPIs basieren. Durch die Integration unterschiedlicher Wissenssysteme – einschließlich interdisziplinärer, lokaler und indigener Perspektiven – trägt LKPC zur Verbesserung der epistemische Qualität von SPIs bei und gewährleistet somit ein umfassenderes und kontextuell relevanteres Verständnis von Klimamaßnahmen. Zudem wird die Partizipation gestärkt: Durch transparente, inklusive und zugängliche Prozesse gelingt es, die oft bestehende Kluft zwischen wissenschaftlicher Expertise und der praktischen Einbindung verschiedener Interessengruppen zu überbrücken. Basierend auf den empirischen Erkenntnissen aus den vier Klimaschutzplanerstellungsprozessen und der Forschung zum IPCC wird argumentiert, dass LKPC zu kontextgerechteren Klimamaßnahmen beiträgt, welche mit höherer Wahrscheinlichkeit umgesetzt werden und somit die Effektivität von SPIs verbessert. Außerdem wird zu gerechteren Klimamaßnahmen beigetragen, indem die Bedürfnisse derjenigen, die am stärksten von den Auswirkungen des Klimawandels betroffen sind, adressiert werden.

Den zentralen Beitrag dieser Arbeit stellt die Entwicklung des LKPC-Konzepts dar, das einen neuen Rahmen für die Gestaltung SPIs bietet und damit gerechtere und wirksamere Klimaschutzmaßnahmen auf allen Ebenen ermöglicht. Auf konzeptioneller Ebene zeigt die Arbeit auf, wie die Integration von Legitimität und Koproduktion sowohl erkenntnistheoretische als auch partizipative Herausforderungen bewältigen und die Kluft zwischen Wissensproduktion und politischer Praxis überbrücken kann. Die empirischen Erkenntnisse aus der Analyse lokaler und globaler Schnittstellen – von städtischen Klimaschutzplänen bis zum IPCC – zeigen konkrete Wege auf, wie Hindernisse für Inklusivität, Reflexivität und Transparenz überwunden werden können. Für die Praxis liefert die Arbeit umsetzbare Empfehlungen, wie Akteure an wissenschaftspolitischen Schnittstellen legitime Koproduktionsprozesse gestalten können, um kontextgerechte, inklusive und besser umsetzbare Klimaschutzmaßnahmen zu entwickeln. Damit verdeutlicht diese Dissertation, dass legitime Koproduktionsprozesse an der Schnittstelle von Wissenschaft und Politik einen wesentlichen Beitrag zu gerechteren Antworten auf die Klimakrise leisten können.

Resumo

A mudança climática é um dos desafios mais urgentes do nosso tempo, com consequências de longo alcance para as sociedades e os ecossistemas naturais. Seus impactos afetam desproporcionalmente aqueles que menos contribuíram para as emissões de gases do efeito estufa, tornando a um desafio profundo de justiça. Abordar essa questão complexa e multifacetada de justiça exige integrar o conhecimento à formulação de políticas. Apesar do papel crítico das interfaces entre ciência e política (*Science-Policy Interfaces*, SPIs) instituições que conectam conhecimento e formulação de políticas, na luta contra as mudanças climáticas, os enfoques existentes frequentemente falham em integrar efetivamente sistemas de conhecimento diversos e engajar de maneira significativa as partes interessadas. Baseada em quatro públicações, esta dissertação explora como as SPIs podem ser aprimoradas para promover ações climáticas mais eficazes e justas.

Para estabelecer a base dessa investigação, após a introdução, o segundo capítulo faz uma revisão sistemática da literatura existente sobre SPIs no campo da sustentabilidade ambiental. Ele identifica os principais tipos de SPIs, seus resultados e seus impactos na formulação de políticas. As descobertas demonstram que SPIs influenciam significantemente a formulação da agenda de políticas públicas. O capítulo destaca fatores que contribuem para a eficácia das SPIs, incluindo a participação de partes interessadas, interdisciplinaridade, diversidade de formações dos especialistas e a comunicação eficaz de conhecimentos complexos. Ao enfatizar a importância da eficácia conforme descrito na literatura, o capítulo prepara o terreno para examinar como a legitimidade pode fortalecer ainda mais a capacidade das SPIs de promover ações climáticas justas.

Com base nas compreensões provenientes da revisão sistemática, o terceiro capítulo defende uma mudança inovadora da eficácia das SPIs para a sua legitimidade como um caminho para promover ações climáticas justas. Ao integrar a literatura sobre SPIs com a pesquisa sobre legitimidade por meio de uma revisão integrativa da literatura, o capítulo oferece a principal contribuição teórica da dissertação. Reconhecendo que as SPIs são inerentemente poderosas e políticas, ao invés de apolíticas e neutras, o capítulo desenvolve um marco para avaliar a legitimidade das SPIs em três dimensões: *input*, *throughput* e *output*. A legitimidade de *input* enfatiza a inclusividade, a transdisciplinaridade e a integração de sistemas de conhecimento diversos para garantir que múltiplas perspectivas informem a produção de conhecimento. A legitimidade de *throughput* foca em elementos processuais como transparência, reflexividade e responsabilização para garantir justiça e acessibilidade. A legitimidade de *output* avalia a eficácia, compreensibilidade e disseminação dos resultados das SPIs para garantir sua relevância e impacto. Ao avançar com esse quadro lógico o capítulo ressalta como a legitimidade pode melhorar o papel das SPIs na abordagem dos desafios de justiça colocados pela mudança climática.

O quarto capítulo aplica o quadro lógico de legitimidade para analisar como as SPIs locais podem ser aprimoradas para promover ações climáticas justas. Ao examinar o desenvolvimento de planos de ação climática urbana (*Urban Climate Action Plans*, UCAPs) em Accra (Gana), Bonn (Alemanha), São Paulo (Brasil) e Ahmedabad (Índia), com base em 73 entrevistas semi-estruturadas e análises documentais, o capítulo fornece entendimento comparativos sobre como os UCAPs são criados e em que medida diferentes critérios

de legitimidade são cumpridos. Ele destaca o papel crucial das organizações que trabalham com redes de cidades no apoio e financiamento dos processos de UCAP. O capítulo revela diferenças significativas entre os casos em termos de coprodução, transparência e participação. Essas variações demonstram como o fomento a processos coprodutivos, inclusivos e transparentes pode reduzir as lacunas de conhecimento e possibilitar ações climáticas urbanas justas.

Expandindo a perspectiva analítica da escala local para a global, o quinto capítulo analisa o IPCC para identificar caminhos que aprimorem seu papel na promoção de ações climáticas justas. Por meio da análise qualitativa de 46 entrevistas com cientistas e formuladores de políticas do IPCC, o capítulo revela como lógicas modernistas, que tratam o IPCC como uma fonte de conhecimento apolítica e universal, moldam suas operações. No entanto, também identifica esforços emergentes para „desaprender" essas limitações, ampliando a diversidade disciplinar, incorporando epistemologias diversas, como o conhecimento indígena, e fomentando produções colaborativas entre cientistas e formuladores de políticas. Essas mudanças indicam caminhos potenciais para aprimorar a legitimidade do IPCC, alinhando-o mais estreitamente aos princípios de justiça nas ações climáticas.

Sintetizando os achados desses capítulos, a dissertação argumenta que a Coprodução Legítima de Conhecimento e Política *(Legitimate Knowledge-Policy Co-Production*, LKPC) oferece um quadro lógico inovador para combinar coprodução com princípios de legitimidade, distinguindo-se de abordagens que se baseiam principalmente na eficácia e em uma visão apolítica e neutra das SPIs. Ao integrar diversos sistemas de conhecimento, incluindo perspectivas interdisciplinares, locais e indígenas, a LKPC melhora a qualidade epistêmica das SPIs, garantindo uma compreensão mais abrangente e contextual das ações climáticas. Ao mesmo tempo, ela fortalece a qualidade da participação ao promover processos transparentes, inclusivos e acessíveis que reduzem a distância entre a expertise científica e o engajamento significativo das partes interessadas. Com base nas percepções empíricas dos quatro processos de criação de UCAPs e da pesquisa sobre o IPCC, argumenta-se que a LKPC contribui para a eficácia das ações climáticas - adaptadas a contextos específicos com maior probabilidade de implementação - e para a justiça, atendendo às necessidades daqueles mais vulneráveis aos impactos das mudanças climáticas.

A contribuição mais abrangente desta dissertação está no desenvolvimento da LKPC para reimaginar as SPIs para promover ações climáticas justas e eficazes em diferentes escalas. Conceitualmente, redefine como as SPIs podem integrar legitimidade e coprodução para enfrentar desafios epistêmicos e participativos, reduzindo a lacuna entre a produção de conhecimento e a formulação de políticas. Empiricamente, a dissertação oferece entendimento de SPIs locais e globais - nomeadamente, os processos de criação de UCAPs e o IPCC - destacando caminhos para superar barreiras à inclusividade, reflexividade e transparência. De forma prática, os achados fornecem orientações acionáveis para os stakeholders das SPIs aprimorarem processos legítimos de coprodução para garantir ações climáticas que sejam contextualmente relevantes, inclusivas e mais propensas a serem implementadas. Por fim, este trabalho destaca que, por meio de processos legítimos de coprodução que unem conhecimento e política, as SPIs podem reduzir a lacuna entre conhecimento e ação, alcançando respostas centradas na justiça para a crise climática.

Declarations

Declaration of Competing Interests

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this dissertation.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this dissertation, the author used 'Grammarly', 'Claude.ai' and 'ChatGPT' to improve language and readability in editing parts of the articles and the frame-text and used 'Deepl' for translating the executive summary into German and Portuguese as well as translating into English the interviews not conducted in English. After using these tools/services, the author reviewed and edited the content as needed and takes full responsibility for its content[1]. The use of these tools/services has been declared during the peer-review process of the three latest publications included in this cumulative dissertation in chapters three to five.

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[1] The text of this declaration has been adapted from Elsevier's standard declaration on the use of AI-tools in academic writing.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ACTA	Applicability, Comprehensiveness, Timing and Accessibility
AI	Artificial Intelligence
AMA	Accra Metropolitan Assembly
AMC	Ahmedabad Municipal Corporation
AR	Assessment Report
BEIS	Ministry for Business, Energy, and Industrial Strategy, UK
BMUV	Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, Germany
CDR	Carbon Dioxide Removal
COP	Conference of the Parties
CRELE	Credibility, Relevance, and Legitimacy
ECPR	European Consortium for Political Research
EU	European Union
FAIR	Findable, Accessible, Interoperable, and Reusable
GEA	Global Environmental Assessments
GEO	Global Environmental Outlook
GRAA	Global Research and Action Agenda
GRULAC	Group of Latin America and the Caribbean
GST	Global Stocktake
ICLEI	International Council for Local Environmental Initiatives
IDOS	German Institute for Sustainability and Development Research
IIFBES	International Indigenous Forum on Biodiversity and Ecosystem Services
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
LANUSYNCON	LANd Use SYNergies and CONflicts within the framework of the 2030 Agenda (Project at ZEF)
LLM	Large Language Models
MEA	Multilateral Environmental Agreement
NAP	National Adaptation Plans
NDC	Nationally Determined Contribution
PhD	Doctor of Philosophy
PPE	Politics, Philosophy and Economics
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RSO	Research and Systematic Observations
RQ	Research Question
SB	Subsidiary Body
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SDG	Sustainable Development Goal
SED	Structured Expert Dialogue
SPI	Science-Policy Interface
SPM	Summary for Policymakers
SR	Special Report
STS	Science and Technology Studies
SUP	Summary for Urban Policymakers
TSU	Technical Support Unit

UN	United Nations
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
WEIRD	Western, Educated, Industrialised, Rich, and Democratic
WEOG	Western European and Others Group
WG	Working Group of the IPCC
WMO	World Meteorological Organisation
YOUNGO	Youth Non-Governmental Organisations (Youth Constituency under UNFCCC)
ZEF	Zentrum für Entwicklungsforschung (Centre for Development Research)

Acknowledgements and Foreword

This dissertation is the result of a long journey - not only because substantial parts were written during tens of thousands of kilometres of train and bus journeys, but also because it has been quite an intellectual journey over the last three and a half years. This journey has allowed me to learn, grow, reflect and think in ways for which I am immensely grateful. I would like to express my heartfelt thanks to all those who have been part of this journey and accompanied me along the way, naming a few of them here:

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Creative Start

Harmony

Green cities breathe, rivers run clear,

Future's unburdened, nature held dear.

Communities thrive in spaces shared,

Earth's wisdom heard, her bounty spared.

Biodiversity blooms unconfined,

Knowledge diverse, with action aligned.

In this world reimagined, climate-just and free,

We've learned to live in harmony.

Niklas Wagner[2]

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[2] Poem co-created together with the AI-tool 'Claude.ai'.

CHAPTER 1: INTRODUCTION

1. Introduction

The poem before paints a vision of a harmonious, climate-just world - a vision this cumulative dissertation seeks to scholarly contribute to through realising such a future by re-examining the integration of knowledge and policy to foster just climate action. The introduction of this dissertation begins by outlining the background and relevance of this topic and then presents the dissertation's objectives and research questions. It continues by introducing the dissertation's overall framework and its methods, including a reflection on my positionality. This introductory chapter concludes by outlining the structure of the dissertation.

1.1 Background and Relevance: Bringing together Knowledge and Policymaking for Addressing the Climate Crisis

Climate change stands as one of the most pressing crises of our time, with far-reaching consequences for both human societies and natural ecosystems. Already today with an increase in the global mean temperature of 1.5 degrees Celsius, the impacts of climate change range from rising sea levels destroying homes and cultures to increasing temperatures making many parts of the world unliveable and to extensive biodiversity loss (C3S, 2024; IPCC, 2018a). Given the scale and depth of the effects of climate change and the fact that they are mostly felt by those who contributed least to this crisis, the transformation required for tackling the climate crisis can be seen as humanity's most profound justice challenge of our time (Robinson, 2011b).

Addressing this complex and multifaceted justice challenge requires bringing together knowledge and policymaking (Balvanera et al., 2020; Kates et al., 2001; Norström et al., 2020). It is for this reason that institutions bringing knowledge and policymaking together have gained importance in modern societies for addressing sustainability challenges (Kowarsch & Jabbour, 2017). Understood as processes or organisations created to enhance the connectivity between knowledge and policymaking, so called Science Policy Interfaces (SPIs) are often thought of as "social processes that involve interactions between scientists and other actors in the policy process allowing for exchanges, co-evolution, and joint construction of knowledge to enrich decision-making" (van den Hove, 2007, p. 815).

Instead of allowing exchanges, co-evolution, and joint construction of knowledge, however, current configurations of SPIs through the linear or the standard co-production model often limit the substantive interactions between scientists, policymakers and other actors participating in the SPI process. Related to positivist perceptions of science being objective and neutral (Merton, 1979; Popper, 1972), SPIs working under the linear model often focus exclusively on scientific knowledge, failing to substantively include other stakeholders or forms of knowledge (Sarewitz, 2004)[3]. Covered behind a veil of neutrality and apoliticalness, linear model SPIs risk being perceived as authoritative, countering democratic ideals of participation (Bader, 2014; Bansard & Hel, 2022; Latour, 2004; Pickering et al., 2022; Turner, 2001).

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[3] Positivism can be defined as social scientific inquiry aiming to strive to reveal universal principles that govern human behaviour and societal phenomena, emphasizing quantifiable data and causal relationships (Creswell, 2013)

SPIs working under the standard co-production model, in contrast, explicitly aim to include diverse stakeholders and their knowledges into the SPI process. However, given that possible power imbalances between these stakeholders in this standard model are not considered, not everyone formally participating might be able to contribute in practice (Lahsen & Turnhout, 2021; Turnhout et al., 2020). With this, SPIs both working under the linear and the standard co-production model risk reinforcing instead of solving the problems they intend to address.

The negative implications of failing to adequately include stakeholders and their knowledge in determining climate actions in SPI processes can be illustrated with measures being counterproductive instead of helpful for adapting to the consequences of climate change. Referred to as "mal-adaptation" (Schipper, 2022), these measures intended for adaptation increase instead of reduce vulnerability, often because the views of local stakeholders and their knowledge are not adequately taken into account (Glover & Granberg, 2021; Magnan et al., 2016; Shah et al., 2024). Not considering relevant knowledge for designing these adaptation measures contributes to climate action harming instead of supporting those most vulnerable to the climate crisis.

These implications of SPI based on the linear and the standard co-production model raise critical questions of justice, particularly in how knowledge production and policy processes shape who is heard, whose knowledge counts, and whose interests are prioritised. By privileging scientific knowledge and powerful stakeholders, SPIs risk reproducing epistemic inequities, excluding communities most affected by the climate crisis from contributing to just solutions. Addressing these implications for fostering just climate action requires transforming SPIs. This dissertation will examine how these institutions connecting knowledge and policy can be restructured to advance climate-just futures by enabling equitable participation and diverse epistemic contributions in policymaking processes.

1.2 The Research Project

The research presented here aims to critically assess how institutions connecting knowledge and policymaking can be enhanced to foster just climate action. Before presenting this research along with its foundations and contributions, this subsection provides conceptualisations of important terms of this dissertation – namely knowledge, science, policy, SPIs, and just climate action.

Key Terminology for this Research Project

Starting with knowledge, knowledge is understood in this research as "intersubjectively shared reality" (Berger & Luckmann, 1967, as cited in Hornidge et al., 2020, p.1499) and hence encompasses "everything which is regarded as knowledge by society" (Berger & Luckmann, 1967, p. 16). Shaped by different languages, cultures, and power dynamics, what is regarded as 'knowledge' differs across societies (Gergen, 1999). However, in terms of policy-relevant knowledge, modern societies dominantly consider scientific knowledge as the most pertinent knowledge for policymaking (Gibbons et al., 1995; Pielke, 2007). With a Newtonian-positivist understanding of science based on universality, rationality and objectivity prevailing

(Merton, 1979; Newton, 2016; Popper, 1972), it is science that is the primary knowledge guiding policymaking in modern societies.

Reflecting the path-dependency of considering science as a dominantly valid and credible source of knowledge for guiding policy, institutions bringing knowledge and policy together in modern societies are often called SPIs (Wagner et al., 2023). While conceptualisations of SPIs range from broad interpretations of the intersections between knowledge and policy systems to more narrowly focused formal organisations (Sarkki et al., 2020; Timaeus et al., 2011), this work adopts van den Hove's widely cited definition of SPIs. SPIs here are understood as "social processes encompassing relations between knowledge holders and other actors in the policy process, allowing for exchanges, co-evolution, and joint construction of knowledge to enrich decision-making" (van den Hove, 2007, p. 815)[4]. This definition accommodates the variety of SPI formats examined throughout this dissertation, including SPIs defined as purposefully set up platforms, as policy creation processes or as intergovernmental panels. While linguistically misleading, SPIs do not point to the exclusive usage of scientific knowledge but can include as well other forms of knowledge, such as Indigenous or local knowledge. However, science remains a cornerstone of SPIs, serving as the default knowledge type for guiding policymaking in most cases.

Policymaking in this research is understood as the decision-making processes leading to tangible actions – specifically climate actions which are understood as measures to mitigate greenhouse gas emissions and adapt to climate change impacts. However, climate actions are inherently normative, raising fundamental questions about whose interests are served, whose knowledge counts, and how benefits and burdens are distributed (Eriksen et al., 2015; Fazey et al., 2018). The explicit focus on 'just climate action' throughout this work acknowledges that climate action must go beyond technical solutions to address underlying patterns of vulnerability and inequality, centring those most vulnerable, often living in the Majority World (Geels, 2005; Scoones, 2016)[5]. This framing centres on those most impacted by climate change contributing to discussions about how climate action can avoid reproducing existing inequalities and instead foster more equitable and sustainable futures.

Objectives and Main Argument of this Research Project

Building on the understanding of SPIs and just climate action laid out, the overarching research question guiding this work is: *How can SPIs be enhanced to foster just climate actions?* This broad inquiry is explored through four publications guided by interconnected sub-questions that form the body of this cumulative dissertation (illustrated in Figure 1):

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[4] For underlining that this joint construction of knowledge is not only about bringing together scientists and policymakers but about bringing together different knowledges and their respective knowledge holders, the term 'scientists' has been replaced with knowledge holders relative to the original definition of van den Hove (2007, p.815).
[5] Following Alam (2008) I refer to 'Majority World' and 'Minority World' instead of 'Global North' and 'Global South' throughout the dissertation ,except for Chapter 2 given that this Chapter was written at the beginning of this project. These terms are coined by Alam (2008) and challenge traditional dichotomies that imply hierarchies of development helping to deconstruct colonial narratives that have historically marginalized non-Western societies while promoting a more equitable understanding of global dynamics.

1. How does the existing literature portray ways of enhancing SPIs in the realm of environmental sustainability? (Chapter 2)

2. To what extent can legitimacy enhance SPIs to foster just climate actions? (Chapter 3)

3. How can urban climate action plan creation processes be enhanced to foster just climate actions? (Chapter 4)

4. How can the IPCC be enhanced to foster just climate actions? (Chapter 5)

These research questions are addressed through four chapters that build upon each other to provide a comprehensive understanding of SPI enhancement. Chapter 2 lays the groundwork through a systematic literature review of SPIs in environmental sustainability. This review synthesises existing scientific knowledge about SPI types, effectiveness factors, and their impacts on policymaking, revealing critical gaps in understanding how SPIs are powerful in fostering change. Building on these insights, Chapter 3 shifts the focus from effectiveness to legitimacy, developing a novel theoretical framework that considers input, throughput, and output dimensions of what is then called SPI legitimacy. Acknowledging that SPIs are more than merely apolitical and policy-neutral, in this chapter it is argued that SPI legitimacy can be used to justify the power of SPIs. Chapter 4 applies this framework empirically, examining how legitimacy manifests in the creation of urban climate action plans (UCAPs) across four different global cities. Moving from the local to the international level, Chapter 5 takes a critical perspective on the IPCC as an example of one of the most prominent SPIs, examining how modernist logics shape its work and identifying pathways for unlearning these modernist logics. Together, these chapters trace a journey from theoretical foundations to practical applications at urban and global levels for what is then called legitimate knowledge policy co-production (LKPC).

Moving from the linear model over the standard co-production model to LKPC, LKPC contributes to unlearning the modern imaginary of SPIs, thereby enhancing SPIs for fostering just climate action. LKPC comprises different forms of knowledge – ranging from scientific knowledge to more local forms of knowledge of local citizens, for instance, and underlines the importance of procedural criteria such as accessibility, transparency and accountability. With this, it is argued that LKPC can be helpful in four main ways for enhancing SPIs for better addressing the climate crisis: *First,* LKPC can help navigate the epistemic complexity of climate change by enabling the integration of diverse knowledge systems and bridging the gap between knowledge and policy implementation. *Second,* LKPC can play an important role in strengthening the participatory legitimacy of SPIs, countering concerns of the "epistemisation of the political realm" (Bogner, 2021) by enabling more participatory and inclusive decision-making processes. *Third,* through these processes, LKPC can enhance policy effectiveness by improving the quality and relevance of policy decisions, enabling more implementable, context-appropriate solutions. This leads to the *fourth point* of why LKPC helps address the climate crisis. By inclusively integrating diverse perspectives with a focus on context-appropriate solutions, LKPC centres those most vulnerable to the climate crisis and thereby contributes to just climate actions.
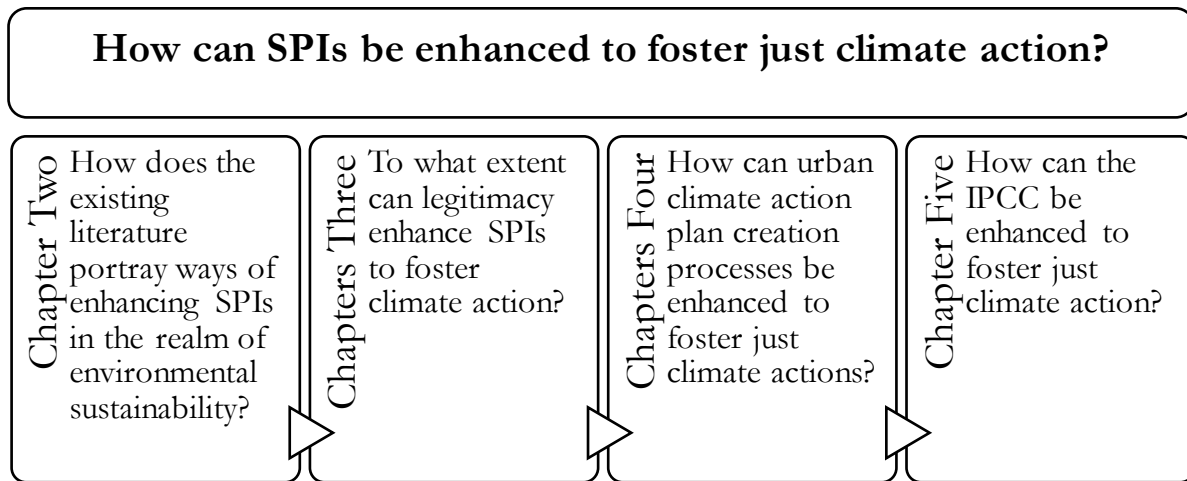
Figure 1: Main research question and sub-research questions answered with the dissertation

Foundations and Contributions: Building on Sustainability Science and Beyond

Conceptually, the research presented here draws on and offers a contribution to a range of discussions that originate from the Sustainability Science literature, which examines how sustainability challenges can be addressed, for instance, through effective SPIs (Cash et al., 2003; W. C. Clark & Dickson, 2003; Kates et al., 2001). However, to address the limitations of this literature in understanding power dynamics and knowledge hierarchies, the research draws on three complementary bodies of literature. The Science and Technology Studies (STS) literature provides critical perspectives on how knowledge is produced and validated in different societal contexts (e.g. Jasanoff, 1994, 2004; Latour, 1993a, 1993b, 1999), helping to unpack the social construction of scientific knowledge in SPIs. The Political Philosophy literature, particularly work on legitimacy (e.g. Habermas, 1971; Rawls, 2005; Scharpf, 1999; Schmidt, 2013), complements this by providing theoretical foundations and criteria for procedurally well-designed policy processes. Post-colonial Theory and Feminist Literature further strengthen the analytical framework by illuminating how historical power relations and cultural contexts shape knowledge systems, challenging Western-centric approaches to knowledge production and policymaking (e.g. Chakrabarty, 1992; Harding, 2008; Mignolo, 2011). Based on this literature, the conceptual contributions lie in introducing and operationalising a legitimacy framework for assessing SPIs in climate action contexts, moving beyond linear and standard co-production towards LKPC.

The conceptual contributions of this dissertation lie in developing novel frameworks for understanding and enhancing SPIs in climate governance. The research introduces and operationalises a legitimacy framework for assessing SPIs in climate action contexts, moving beyond traditional effectiveness measures. Additionally, it offers critical theoretical insights into how modernist logics shape global climate governance institutions and their knowledge-policy interactions.

Empirically, this dissertation builds upon and contributes to the literature examining SPIs at the local and the global scale, namely the urban transitions and the IPCC literature. The urban transitions literature

explores how cities engage with climate change knowledge and how they translate it into action, examining the role of city networks, institutional capacity, and local contexts in shaping climate responses (e.g. Bulkeley, 2010; Cashmore, 2018; Hughes & Hoffmann, 2020). Based on this literature, the empirical contributions of this research of this dissertation advance the understanding of knowledge-policy interactions in climate governance through an in-depth analysis of cities' climate action plans' creation processes providing new insights into how cities across different global contexts integrate knowledge into local climate policymaking.

Focused on one of the world's most prominent SPIs, the IPCC literature investigates how scientific credibility and political relevance as well as the concept of climate change, are created within the IPCC (e.g. Beck, 2012; de Pryck & Hulme, 2022; Hughes, 2024). This research contributes to an understanding of the IPCC through the lens of modernity and the need for unlearning it. This contribution to the existing IPCC literature offers a novel perspective on this global knowledge institution, revealing how deeply embedded modernist assumptions influence global climate governance and suggesting pathways for institutional enhancement.

Throughout this work, concrete societal relevance has been a guiding principle, with each chapter offering specific policy recommendations to enhance knowledge-policy interactions for just climate action. Chapter 2 provides recommendations for SPI stakeholders, encouraging them to diversify outputs, utilise identified effectiveness factors, and reflect on institutional SPI design to move towards a co-production model. The theoretical framework developed in Chapter 3 operationalises the concept of 'SPI legitimacy' in a way that can be broadly applied across different contexts and governance levels. This practical applicability is particularly evident in Chapter 4, where the framework's implementation in urban settings yields specific insights and recommendations for urban policymakers and city network officials, detailed in Appendix 4-1. Chapter 5 recommends broadening the substantive participation of knowledge holders from the Majority World, establishing clear criteria for the inclusion of Indigenous and local knowledge, and adopting knowledge-policy co-production as a guiding principle for the IPCC. The policy recommendations throughout this dissertation underscore the transformative potential of this research in reshaping how knowledge and policy interact to address climate challenges in a more equitable and just manner.

1.3 Legitimacy, Knowledge Policy Co-Production and Just Climate Actions

Building upon the literature mentioned above, this subsection outlines the theoretical framework of this dissertation and its four publications. It begins by examining how modernity and functional differentiation have shaped the climate crisis and the separation of scientific and political spheres, exploring the evolution of SPI literature in sustainability science. It then introduces 'standard co-production' as a way of unlearning the modern imaginary which then forms the basis for introducing LKCP contributing to just climate actions.

Modernity as Starting Point of Climate Change

Climate change represents one of humanity's most profound justice challenges, characterised by the disconnect between those who have contributed most to the crisis and those who bear its heaviest burdens (Robinson, 2011a). Already with today's global mean temperature increase, the impacts are severe and far-reaching: Rising sea levels threaten homes and cultural heritage, increasing temperatures render parts of the world gradually uninhabitable, and accelerating biodiversity loss and ecosystem instability (C3S, 2024; IPCC, 2018a). Climate change disproportionately harms vulnerable communities and future generations, who contributed least to emissions, making it a profound issue of global justice rather than merely a technical challenge (Ikporukpo, 2022; Lahn, 2018; Lefstad & Paavola, 2023).

To fully grasp the justice implications of the climate crisis, it is understood in this research within the context of modernity and its underlying logics. Modernity can be characterised by its ideals of progress and industrialisation, which in turn are often equated with economic growth and industrial development (Rostow, 1990; P. Wagner, 2012, p. 28; Weber, 1946, 2001). Acknowledging that modernity is neither a linear nor universal undertaking with a singular definition (Eisenstadt, 2000), it has been argued that the modern project's fundamental contradiction lies in the pursuit of infinite economic growth on a finite planet (Murphy et al., 2021). Given the 'development' of resources from colonies on this finite planet, modernity and colonialism are considered a conceptual pair (Arora & Stirling, 2023; Bhambra, 2007; Brunner, 2021; WGBU, 2023). While modernity delivered material prosperity for some, it has created what the post-colonial scholar Mignolo (2011) terms the "dark side of modernity"- a legacy of environmental degradation, social inequality, and cultural disruption devastating for big parts of the world's population and its ecosystems.

Procedurally, it can be argued that modernity is built upon the Enlightenment's emphasis on rationality manifesting in a profound trust in Western science to uncover objective truths about the world (P. Chatterjee, 1998; Latour, 1993b). This trust in science is related to the perception of science as an independent source of universal and objective knowledge, allegedly separated from societal contexts. With the increasing trust in science in modern societies, science can be considered a driving force of 'modern progress' (Harding, 2008). Modernity's emphasis on Western scientific knowledge as the dominant form of understanding has marginalised other ways of knowing and relating to the natural world, contributing to the very patterns of thought and action that have accelerated climate change (Aquino, 2020; Chakrabarty, 2007, 2009; Vries, 2024).

This marginalisation of diverse knowledge systems is further reinforced by modernity's functional differentiation of society into semi-autonomous subsystems (Luhmann, 2012; Parsons, 1970). Each subsystem operates according to its own internal logic and specialised codes, with Western science following a rigid true/false binary in pursuit of empirical validation, whereas politics operates through the code of power and decision-making (Baraldi et al., 2021; Fuhse, 2005). This differentiation not only privileges Western scientific knowledge within modernity's knowledge-production subsystem but also creates significant barriers to incorporating other ways of knowing into policy processes. According to systems theory, these subsystems can only "irritate" rather than substantively influence each other (Hornidge et al.,

2018). This disconnected between 'objective and value-free' scientific knowledge from more value-laden political decision-making, the SPI literature argues, has hampered society's ability to develop holistic responses to the climate crisis as will be shown below.

Science Policy Interfaces for Addressing Climate Change

Within the field of sustainability science, SPIs have emerged as a response to the modern disconnect between knowledge and politics. Over the last two decades, a growing body of literature has examined how SPIs can better integrate research, monitoring, assessment, and decision support into systems for adaptive management and societal learning (Dinesh et al., 2021; Matsumoto et al., 2020; Tinch et al., 2018). While various terms such as "knowledge platforms" (Esguerra & van der Hel, 2021) or "boundary organisations" (Guston, 2001; Hoppe et al., 2013; Mollinga, 2010) are used somewhat interchangeably in the literature, SPIs are most commonly understood as social processes facilitating interactions between scientists and other actors in the policy process (van den Hove, 2007).

Within these interfaces, knowledge and policy are transformed into tangible outputs such as policy briefs, reports, assessments, and dialogue (Sarkki et al., 2015). This iterative process allows for the integration of different forms of knowledge and interests and takes various forms, ranging from informal networks bringing together individuals to highly institutionalised platforms connecting different organisations (Dunn & Laing, 2017; Timaeus et al., 2011).

The degree of institutionalisation and the specific format of SPIs often depend on the scale and context in which they operate, as evidenced by the two primary examples examined in this dissertation, namely UCAP creation processes at the local level and the IPCC at the global level in Chapters 4 and 5. UCAP creation processes can be understood as SPIs where knowledge and political interests converge to shape urban climate transformations when creating a city's climate action plan. These plans are documents that integrate knowledge and policy and thereby determine cities' climate mitigation and adaptation actions for decades to come (Deetjen et al., 2018; Reckien et al., 2018). The creation processes of UCAPs exemplify how SPIs can be understood as policy-knowledge creation processes. In contrast, the IPCC can be understood as an SPI organisation bringing together thousands of scientists with representatives from member states of the United Nations to produce authoritative knowledge assessments for guiding climate policy (Kouw & Petersen, 2018; Lidskog, 2024; Livingston, 2022). Given the centrality of its scientific assessments intended to guide climate policy at different levels, the literature describes the IPCC to be based on the so-called 'linear model' (Beck, 2011; Hulme et al., 2010).

Characterised by science one-directionally "speaking truth" to policymaking (Price, 1981; Weingart, 1999), the linear model resembles characteristics of procedural modernity, placing a profound emphasis on scientific knowledge, following the logics of functional differentiation, with science only 'informing' policymaking instead of both systems substantively influencing each other. It is for this reason that, while designed to overcome the disconnect between science and policy through SPIs, SPIs built upon the linear

model might reinforce instead of contributing to solutions for addressing the multiple sustainability challenges, with the literature calling for unlearning this modern approach to SPIs discussed subsequently.

Unlearning Modernity within SPIs through 'Standard Co-Production'

There is a growing recognition in the literature that modern approaches to SPIs - characterised by the linear model and a focus on Western scientific knowledge - are inadequate for addressing the climate crisis. This recognition has led to calls for fundamental change in how SPIs operate, a process that is called 'unlearning modernity' in Chapter 5. Unlearning modernity can be understood as "the critique and moving beyond the modern imaginary" (Rösch, 2017), and in the context of SPIs, refers to the institutional and procedural transformation through which these interfaces critically examine and move beyond their embedded modern assumptions.

In this research, a first step towards unlearning modern imaginaries in the context of SPIs is presented as 'standard co-production'. Challenging the modern conception of 'objective and neutral science', it presents an alternative approach to bridge the modern disconnect between knowledge and policymaking. Standard co-production is emphasised as a means to reimagine and strengthen the relationship between knowledge production and decision-making (J. M. Chambers et al., 2021; Munoz-Erickson, 2014). Rather than maintaining a rigid separation between knowledge and policy spheres, standard co-production involves iteratively bringing together diverse knowledge holders and policymakers to „reason together" (Koetz et al., 2012; Wyborn et al., 2019). This approach fosters collaborative processes that iteratively integrate diverse perspectives throughout all stages of knowledge creation and policy development[6].

Importantly, in contrast to the linear model, standard co-production is characterised by moving beyond the narrow confines of Western scientific knowledge to embrace a pluriverse of knowledge systems (Escobar, 2018; Kaul et al., 2022). Depending upon the context of the SPI, this includes actively engaging with and elevating Indigenous and local knowledge systems that have been systematically marginalised by modernity (Ainsworth et al., 2020; Khupe, 2020; Semali & Kincheloe, 2002).

While presenting a first step towards 'unlearning modernity', the standard co-production model itself is criticised as not sufficiently addressing the inherent power asymmetries within SPIs, and thereby risking to reinforce instead of solving the problems they intend to solve (Lahsen & Turnhout, 2021; Turnhout et al., 2020). Building upon these shortcomings, this research argues for LKPC characterised subsequently.

Legitimate Knowledge Policy Co-Production for Just Climate Action

To overcome the shortcomings of standard co-production as discussed above, this dissertation argues for moving from standard co-production towards LKPC, adding a procedural focus to knowledge policy co-

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[6] Following sustainability science literature, co-production refers in this dissertation to the normative aspiration of pro-actively designing science-policy relations (Cash et al., 2006, p.467). However, the analytical value of descriptive co-production describing how science and policy constantly shape each other being embedded in a social and cultural context is regarded as 'de facto reality' is acknowledged (Jasanoff, 1998, 2004; Latour, 1993a, 1999, 2004; Wyborn et al., 2019).

production for enhancing SPIs through characteristics such as reflexivity, accountability, accessibility and transparency.

Resembled under the concept of legitimacy, legitimate in comparison to standard co-production provides a conceptual base for justifying and examining the inherent power of SPIs, acknowledging that these interfaces are not apolitical but powerful in shaping climate action (Beetham, 1991b; Bodansky, 2008). Being about the "the quality of being based on a fair or acceptable reason" (Habermas, 1996, p. 297) the concept of legitimacy can also be extended to the quality of knowledge and hence is analytical valuable for enhancing SPIs (Cerovac, 2020; Oxford Dictionairy, 2022). And given the concept's strong procedural focus, legitimacy is sometimes regarded as the procedural counterpart to the more substantive concept of justice (Pettit, 2012; Rawls, 2005). This makes it particularly suitable for enhancing SPIs for addressing climate change as a justice challenge.

In practice, procedural characteristics of legitimacy for enhancing co-production SPIs improve the meaningful inclusion of diverse stakeholders and their knowledge into SPIs. For instance, 'accessibility' as criterion of legitimacy contributes to stakeholders, formally participating in a co-productive SPI process, to be substantially included for their voices being heard. 'Power reflexivity' in these processes acknowledges the inherent power dynamics within SPI processes and intends to mitigate those through critical reflections upon the dynamics at hand. Putting the SPI process under public scrutiny, 'accountability and transparency mechanisms' are expected to improve power asymmetries within SPIs. With this, LKPC as will be discussed in more detail in Section 6.1 in this dissertation, is conceptualised as approach for enhancing the quality of SPI relative to the linear model as well as the standard co-production model.

1.4 Positionality and Research Operationalisation

In light of the main argument of this research advancing LKPC and respective needs for unlearning the modern imaginaries of the science system, this methods subsection does not only list the methods I undertook for the collection and analysis of my data but starts with introducing my positionality, allowing the reader to trace my epistemological and methodological choices. After this positionality statement, I present the reader the methods undertaken including the literature review, data collection and data analysis as well as ethical considerations related to this dissertation[7].

Positionality Reflections

Considering the theoretical framework discussed above and the argument for LKPC including calls for reflexivity within research, the focus shifts to my identity as a researcher and how I situate myself within my research. Originating from feminist scholarship, positionality involves the critical engagement of researchers

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[7] I would like to acknowledge that this subsection has been significantly benefitted from reading the draft of a methodology chapter of my colleague Altynay Kambekova and led me to combine the positionality and methodology sections. This chapter inspired me and is cited with '(Kambekova, 2024)'.

with their identity and the standpoint from which they approach their own research (P. H. Collins, 2008; Harding, 1992; Kambekova, 2024). Recognising and explicitly stating the influences which shaped me, the following paragraphs will explore how my privilege and positionality, academic background, involvement in climate activism, as well as institutional settings have impacted the research presented here.

My research perspective is shaped by my position as a WEIRD (Western, Educated, Industrialised, Rich, and Democratic) individual. As a white, heterosexual male born, and raised in Germany, a rich industrialised democracy, I have benefited from numerous privileges that have influenced my worldview and academic journey. I grew up in a small village close to Freiburg, with Freiburg relative to the rest of Germany being wealthy, sunny and 'sustainable' with the Green Party being relatively strong there for decades.

However, not only did the broader environment provide stability, but it was also my home that provided me with what I consider a 'fertile soil for a seed to grow'. My parents, both medical doctors and hence not only both academics but also part of Germany's upper class, were able and willing to support me in my educational endeavours. What further shaped me was that I am the oldest of three brothers and hence have taken responsibility from an early age. However, in retrospect, I don't think my main politicisation happened during my upbringing – but happened after a six-month exchange in Argentina during high school. This experience marked my first significant encounter with social injustice that I had not been exposed to at home, contributing to the decision to do a volunteer year in Mexico after finishing high school in 2015, where I was working in rural education activities against poverty.

Shortly afterwards, in 2017, two years before Greta Thunberg rose to prominence and sparked the Fridays for Future movement, I joined the youth - climate advocacy organisation 'Klimadelegation e.V.', attending my first world climate conference. With this I became part of the climate movement advocating for climate justice at the international level through engaging with policymakers. My activism then extended beyond these more formal channels within the political system, including participation in forest and lignite coal occupations in Dannenrod and Lützerath from 2020 to 2023.

Concerning my education, I began my academic journey with a Bachelor's degree in Philosophy, Politics, and Economics (PPE) at the Free University Amsterdam in 2016, which instilled in me a joy for asking questions and provided me with an interdisciplinary foundation for my Master's in Environmental Policy at Cambridge University, with both study programmes being supported by a scholarship from the German Study Foundation (Studienstiftung des Deutschen Volkes). However, relative to more critical and heterodox study programmes, in retrospect, I think both programmes were, relative to fields such as gender studies or STS rather positivist and quantitative, not exposing me to critical theory, post-colonial thought or qualitative research methods.

After the Master's, I applied for a PhD position at the LANUSYNCON[8] project at the Centre for Development Research (ZEF), focusing on global SPIs in the context of Sustainable Development Goals

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[8] Research project titled 'LANd Use SYNergies and CONflicts within the framework of the 2030 Agenda' at the Centre for Development Research in Bonn

(SDGs), more because of my abstract interest in synergies and conflicts between SDGs than my interest in SPIs. Instead of being offered a position there, however, I was offered half a year later a position for comparative political analysis within the 'One Health and Urban Transformation Graduate School' within the same institute. This position came under the condition of comparing urban transformation policies across the study projects' research locations and the liberty to focus on climate-related transformational issues. My supervisory team evolved over the course of my PhD, starting with Prof. Dr Thomas Dietz from political science and law and Jun. Prof. Dr Lisa Biber Freudenberger with a natural science background, and later expanding to include Prof. Dr Anna-Katharina Hornidge with a background in knowledge sociology with especially the latter shaping me and my dissertation. Having acquainted myself with some introductory sociology knowledge in the second PhD year, I found to be a very useful disciplinary addition to my analytical toolkit for better understanding the world and approaching this research. With this, this research reflects the disciplinary backgrounds of my supervisors and hence is to be situated on the fuzzy boundaries between sociology and political science.

In this light, the reader should understand my methodological choices described below. By actively remembering and interpreting my past through my present context, this positionality statement provides an attempt to situate myself in this research. As Kambekova (2024, p.23) points out:

> *„Remembering itself is not just a process of tracing past events chronologically but a bridge between self-reflection and the formation of experiences. It plays a vital role in shaping identities, underscored by the importance of remembering in both research and theories concerning identity and how the latter informs the research process"*

This process of remembering has not only been important for my self-reflection, but I hope also useful for the reader in understanding how certain epistemological and methodological choices in this research have been informed.

Literature Syntheses

The theoretical foundation of this dissertation spans Chapters 2 and 3, with Chapter 2 providing a comprehensive overview of SPIs and Chapter 3 developing a critical theoretical framework for understanding their legitimacy. Chapter 2 employs a systematic literature review following the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). This methodological approach has been designed to comprehensively assess the impact of SPIs on policy development within the environmental sustainability context. The review systematically examines scientific publications from 1990 onwards, utilising a structured search strategy across Web of Science, ScienceDirect, and Google Scholar. By combining search terms related to SPIs, environmental sustainability, and policy impacts, the research conducts a rigorous screening process of the literature[9]. This involves an initial title and abstract review, followed by a full-text evaluation. Studies were selected based on their explicit focus on environmental SPIs and their demonstrated or discussed impacts on policymaking, ensuring a

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[9] Search terms are listed in the Method Section of Chapter 2.

comprehensive overview of SPI effectiveness and policy engagement in the environmental sustainability domain.

While the systematic literature synthesis provides a structured approach to examining scientific publications on SPIs, several significant limitations need to be acknowledged. The reliance exclusively on English-language academic literature excludes potentially valuable insights from non-English and non-scientific sources. The search strategy employed narrow search terms that may not have captured processes which could be considered SPIs, such as UCAPs explored in Chapter 4, but are termed differently in the literature. By focusing on publications from 1990 onwards and relying solely on Web of Science, ScienceDirect, and Google Scholar, the review potentially misses foundational research and relevant studies from alternative academic databases. The analytical framework predominantly focuses on effectiveness factors through the 'credibility, relevance and legitimacy' (CRELE) framework, which limited the exploration of alternative conceptual approaches. By not incorporating grey literature and maintaining a narrow definitional scope of SPIs, the review potentially misses critical, contextual knowledge that could have enriched the understanding of SPIs.

Building upon this systematic review, Chapter 3 critically develops a conceptual framework interrogating the legitimacy of SPIs. Departing from traditional effectiveness metrics, in this chapter it is argued for a fundamental reorientation in evaluating SPIs, challenging their presumed apolitical and neutral character. Methodologically, Chapter 3 adopts an integrative literature review approach, synthesising perspectives from multiple disciplines to generate a novel conceptual framework (Snyder, 2019; Torraco, 2005). Unlike the systematic review's stringent inclusion criteria, this method embraced a more flexible, interpretive approach to literature synthesis. The research draws from an interdisciplinary corpus of literature spanning political science, sociology, sustainability science, and environmental governance research. The analysis employed conceptual reasoning to construct arguments about the legitimacy of SPIs, ultimately deriving a comprehensive framework of 12 criteria for evaluating SPI legitimacy. This methodological strategy allows for an adaptive approach to synthesising diverse literature, generating theoretical insights that challenge the linear understanding of knowledge-policy interactions and the literature's dominant focus on effectiveness.

While Chapter 3 offers a critical intervention in understanding SPIs through the lens of legitimacy, the following limitations warrant acknowledgement. The research's focus on legitimacy is linked to my academic background in Philosophy, Politics, and Economics, and could be directly traced to courses undertaken in Political Philosophy and European Studies where the concept of legitimacy has been covered and hence reflects inherent Western academic biases. Further, while power is mentioned as important in Chapter 3, the framework lacks tools for providing a more nuanced understanding of power relations within SPIs.

Case Study Approach

Informed by the theoretical grounding of Chapters 2 and 3, empirically, this research builds upon fieldwork on the international as well as city level on knowledge policy interactions. Fieldwork conducted in Chapter 4 spanned four cities across different regions of the world: Accra (Ghana), Bonn (Germany), São Paulo

(Brazil), and Ahmedabad (India) and was conducted during field visits of around three months per study location during 2023. The selection of these locations reflects the study locations of the 'One Health and Urban Graduate School' and hence was predetermined since the start of the research project. Starting with this choice, I found these locations to be suitable cases for researching the creation processes of UCAPs with regard to knowledge policy interactions given that in all locations a UCAP has been created in the last five years. While this selection presents a diverse range of urban contexts for analysing the creation processes all embedded in democracies, it is important to acknowledge that without being predetermined by the study project, other case selections with a better degree of comparability would have been preferred.

The cities for this research are diverse in their political institutional settings, socio-economic backgrounds, and climate challenges and it was important for me as researcher to grasp these different contexts. Except for the study site being my hometown, personal conversations, newspapers as well as key-informant interviews about the political contexts proved to be helpful for understanding the study environments. For instance, it was important to learn the centralised nature of local decision-making in Ghana or the importance of federal states for municipal policies in India relative to my home country.

For Chapter 5, interviews were conducted across multiple United Nations Framework Convention on Climate Change (UNFCCC) conferences and sessions. These included virtual sessions of the UNFCCC Subsidiary Bodies in 2021, in-person Subsidiary Body meetings (SB 56 in 2022, SB 58 in 2023, and SB 60 in 2024) in Bonn, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Plenary 9 in 2022 in Bonn, and the UNFCCC Conference of the Parties (COP) meetings - COP 26 in 2021 in Glasgow and COP 27 in 2022 in Sharm El-Sheikh. Except for IPBES 9, these sessions serve as spaces for parties of the UNFCCC and the Paris Agreement to conduct negotiations about the implementation of the framework convention and subsequent agreements such as the Paris Agreement. The SB meetings are held at the location of the UNFCCC Secretariat in Bonn (therefore also known Bonn Climate Conference), while the COPs rotate between regions and are hosted in large conference centres. The June 2021 SB sessions were unique in the history of the UNFCCC as they were conducted online due to COVID-19.

For observing and analysing the IPCC and how it is used by policymakers, these sessions have been very important for understanding the role of the IPCC in international policymaking. COP 26 and SB 56 were particularly relevant for this as they showcased the IPCC's role in presenting their Sixth Assessment Report, with Working Group I presenting at COP 26 and Working Groups II and III at SB 56[10]. Additionally, the IPCC's presence through its pavilion at the COPs for side events, and its mention in all final COP documents, underscored its significance. The IPCC's relevance was especially highlighted in negotiations related to the Global Stocktake (GST) and Research and Systematic Observations (RSO). Regarding the IPBES Plenary 9, its data was not directly used for the research related to the four publications. Due to the lack of access to the IPCC at that time, however, it provided valuable insights into the interactions between

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[10] Working Group I of the IPCC works on the physical science basis of climate change, while Working Group II focuses on impacts, adaptation, and vulnerability, and Working Group III addresses the mitigation of climate change.

policymakers and scientists of a prominent international SPI[11]. Appendix C-4 details key learnings from this session.

Access to these international sessions was formally restricted, requiring university registration and being limited by the number of observer badges available[12]. Unlike in the fieldwork related to urban climate plans, given my earlier experience in climate activism at COPs, I have been relatively familiar with the study environment providing a solid base for the data collection of this dissertation detailed below.

Data Collection

The primary method employed for data collection in this research was conducting semi-structured interviews. A total of 119 semi-structured interviews were conducted[13]. This approach allowed to adapt the pre-formulated questions during the course of the interview, enabling the exploration of emerging themes and the pursuit of additional questions as they arose, adapting the dialogue to reflect the interviewee's experiences and perspectives (Gill et al., 2008; Kambekova, 2024; Lamnek & Krell, 2010).

For initiating the interview process for Chapter 4, an extensive mapping of stakeholders involved in the respective UCAP was conducted, identifying all potential stakeholders relevant to the study. Stakeholders were contacted primarily via email or phone, with some outreach facilitated through the professional networking platform LinkedIn. In contrast, for Chapter 5, interview partners were directly identified and approached at conference venues, often following related events or negotiations. In selecting interview partners, I maintained an effort for gender and regional balance to ensure diversity in perspectives. As a white, European researcher with academic credentials, my positionality likely influenced both who was willing to engage with me and the dynamics of access and trust during the interview recruitment process – dynamics I took note of and discuss further below. Prior to each interview, I familiarised myself with the interviewee's organisation and position, adjusting the interview guide accordingly to enhance relevance and engagement.

The duration of interviews varied significantly, with some lasting as little as 15 minutes while others extended up to three hours. This variability was influenced by factors such as the stakeholder's level of involvement, their availability, and the rapport established between interviewees and me as the interviewer.

Interviews were conducted in multiple languages to accommodate participants' preferences: English predominated, while German was used for UCAP Bonn interviews, Portuguese for UCAP São Paulo, and Spanish and French were utilised for two interviews at the UNFCCC level. Conducting interviews in native or preferred languages helped to capture a more nuanced view of participants' social realities while minimising potential misinterpretations (Squires et al., 2020; van Nes et al., 2010). However, despite the

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[11] I am happy to note that I managed to register the University of Bonn as observer to the IPCC, making it possible to attend IPCC sessions in the future for members of the University of Bonn. In case of interest for members of the University of Bonn, please contact the Universities' UNFCCC focal point.

[12] As an observer from civil society or academia, participation rights in the 'party-driven' UNFCCC process are limited.

[13] Details on the interviews can be found in Appendices 4-1 and 5-1.

advantage of conducting interviews in five languages, the limitation of these languages being exclusively Western European restricted the ability to engage with respondents in their Indigenous or non-European native languages, potentially overlooking important perspectives and cultural nuances.

Interviews on the IPCC were conducted together with my colleague Sara Velander with the interviews consisting of two parts – one tailored more towards legitimacy and one towards her doctoral study on complexity and collaboration between SPIs with 28 of the interviews being conducted by me and 18 by my colleague. While this had the advantage of capturing more perspectives and helped us both to approach our first semi-structured interview experiences together, the disadvantage of this joint approach was less time for my parts of the interview and hence potentially a reduced depth of some of the answers.

This dissertation involved both virtual and in-person data collection. In-person interviews provided additional contextual insights and allowed for a deeper understanding of the local dynamics, leading to more in-depth conversations and were particularly valuable for building a friendly relationship with interviewees. Further, the locations of these in-person interviews offered additional insights into the institutional dynamics. For chapter 4, most interviews with policymakers took place in their offices within municipal buildings. Interestingly, staff of international city networks such as ICLEI or C40 assisting municipalities with their climate action plans examined in Chapter 4, despite not being under contract with the municipality, were often also located within these municipal premises, suggesting close operational ties. Interviews with scientists typically occurred in university settings, while civil society actors were met in their respective organisational contexts. While in-person interviews were preferred, the possibility of online interviews allowed to access interview partners otherwise not available for the study. For Chapter 4, around a third of the interviews were conducted online, possibly reflecting a newly emerged working culture after the COVID-19 pandemic (DeFilippis et al., 2022). For Chapter 5 less than a tenth of interviews were conducted online.

My positionality laid out earlier in this section significantly influenced not only the selection of interview partners but also their willingness to participate, as well as the interview process and the resulting data – which is important for evaluating both the nature and quality of data obtained throughout the interview process (Briggs, 2005). As a young, white, male European researcher affiliated with the University of Bonn, I was acutely aware of how these characteristics could affect interviewee responses. This awareness prompted ongoing reflection on several key questions: How comfortable were interviewees in sharing genuine insights? What types of information were they willing to disclose? What barriers might exist to open communication? I tried to reflect upon these questions in my field diary.

To triangulate data and capture contextual dynamics surrounding discussions, relevant documents were collected for Chapters 4 and 5. The collection included documents related to interviews as well as other textual materials pertinent to specific UCAPs or IPCC discussions. The UCAP documents varied significantly in length - from less than 50 pages to over 400 pages - and included not only strategies for climate action implementation but also details about their creation processes and contributing actors. For

instance, Bonn's Civil Society Climate Plan included recorded planning sessions available online alongside session notes that were analysed.

For Chapter 5, collaborative fieldnote-taking was conducted during key events related to the research question using an event ethnographic approach (N. Koch, 2023; Zanotti & Suiseeya, 2020). At COP 26 and COP 27, notes were jointly taken with colleagues from various institutions including ZEF and universities from Geneva and Lausanne. While this collaborative approach might have decreased the note-taking quality for some note-takers, overall, it ensured comprehensive coverage of interventions compared to individual note-taking efforts during lengthy sessions.

Data Analysis

Data analysis for this dissertation was conducted to address the respective research questions through a carefully structured methodological approach. An inductive-deductive framework, as outlined by Boyatzis (1998), was employed, which provided an initial coding framework based on the theoretical understanding developed in Chapter 3. This inductive-deductive approach was informed by what Houben (2017) and Mielke & Wilde (2017) describe as mid-range theory development. This concept emphasises the connection between abstract theories and empirical realities, allowing for a more nuanced analysis of the data. As noted by Mielke and Wilde (2017, p.83), „Mid-range theory development is achieved through mirroring empirical data in light of already existing concepts and theories or - as realist social theory would claim - through theory-laden as opposed to theory-determined concept development from empirical realities".

This iterative process ensured that our concepts evolved as new data emerged, maintaining their relevance and applicability throughout the analysis. The resulting framework was designed to be dynamic rather than static, allowing for iterative refinement through team discussions and pilot coding of a subset of interviews. By employing this approach alongside a constant comparison technique (Tesch, 2013), I was able to identify emerging themes and continuously refine the coding structure.

Data transcription was facilitated through paid Artificial Intelligence (AI) software, which was subsequently manually corrected by myself or my research assistants. While this method improved efficiency, it is acknowledged that some richness may have been lost in the analysis because of the reliance on AI for transcription. The decision to use this approach was made in consideration of time constraints associated with completing the PhD. For non-English interviews, translations were performed with AI assistance and carefully reviewed by a native speaker to correct potential mistakes or cultural oversights. Although this process might have led to some loss of cultural insights, I concluded that the benefits of comparability outweighed these disadvantages (McKenna, 2022; van Nes et al., 2010).

Once all interview transcripts and relevant documents were ready for analysis, they were imported into MAXQDA 2022 software for developing the final coding framework. The data was coded primarily by me, with assistance from my research assistant for Chapter 4. This collaborative effort proved beneficial for discussing emerging themes and discrepancies in interpretations. Throughout this reflective activity, we wrote memos to trace our thoughts during the coding process. It is important to acknowledge that both my

research assistant and I are WEIRD male scholars; different perspectives could have contributed additional insights.

To further enhance our analysis, I utilised MAXQDA's analytical tools to conduct cross-tabulations of codes across case studies and stakeholder types. This enabled me to identify patterns and relationships within the data effectively. Thematic analysis was performed to uncover recurring patterns and themes both within and across cases. Additionally, the visualisation tools within the software facilitated the identification of emerging themes, enriching my understanding of the data landscape and supporting a comprehensive analysis aligned with the research objectives.

Ethical Considerations

Ethical considerations are a fundamental aspect of research and play a crucial role in ensuring the welfare of participants, not only essential for compliance with institutional and legal standards but also vital for fostering trust and credibility in research findings. This dissertation adheres to the ethical guidelines set forth by my institution, having received ethical approval under registration code '14c_22 Niklas Wagner' on April 27, 2022. However, ethical approval must also be contextualised within the institutional framework in which it was granted, as the definition of what is considered ethical must always be examined within its respective temporal and local context[14].

Regarding ethical standards within its own temporal and local context, it is interesting to highlight ethical considerations for the use of generative AI Large Language Models (LLM) in scholarly research. As this technical innovation emerged during the time of this research, there were no clear guidelines for the use of AI in research at my institution at the time of conducting and writing this research. Following the approach of the journals chapters 2 and 3 of this dissertation have been published in, the use of AI for editing parts of the text has been declared at the beginning of this dissertation. With the discussion of the ethics of AI in academia being beyond the scope of this paper, it is important to acknowledge the range of problems associated with AI and that merely declaring the use of AI does not mitigate those.

In terms of ethical considerations during data collection, the interview process was designed to prioritise participant autonomy and informed consent (see Appendix I-1 for an exemplary consent form). Participants were fully informed about the research project, including its objectives and methods, prior to each interview. They received detailed information outlining the study's purpose, their role in it, and how their data would be used and protected. Participants were assured of their right to withdraw from the study at any time without facing any consequences. Anonymity and consent were ensured prior to each interview, and interviews were conducted in various languages to accommodate participants' preferences. Efforts were also made to maintain inclusivity and representation, striving for gender and regional balance throughout the research.

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[14] In this regard, it is notable that with the 'Decolonising Knowledge Group' I co-founded during my PhD, we are advocating for the inclusion of positionality statements within ethical approvals of ZEF.

To safeguard participant privacy and confidentiality, stringent data protection measures were implemented. All transcriptions and survey responses were stored on a password-protected online drive accessible only to me and my research assistants. Data anonymisation was achieved by referring to interviews by a continues ID number in Appendices 4-1 and 5-1 with the names of participants documented during sampling being stored separately.

In alignment with the 'FAIR principles' - Findable, Accessible, Interoperable, and Reusable - (Wilkinson et al., 2016) ethical data management practices were followed. Metadata of the interviews, describing their context, collection methods, and participant demographics without compromising anonymity; is detailed in appendices 4-1 and 5-1 and registered in the ZEF data repository (N. Wagner, 2024b, 2024a)[15]. While interview transcripts cannot be openly published due to confidentiality concerns, they can be accessed upon reasonable request. The reusability of data is supported through documentation of how interviews were conducted. Regarding publication practices, the chapters of this cumulative dissertation have been published open-access – supporting the broader availability of the generated knowledge. In closing, this section has outlined the ethical considerations underpinning this research. The next section offers an overview of the dissertation's organisation.

1.5 Outline

The research presented here aims to critically assess how institutions connecting knowledge and policymaking can be enhanced to foster just climate action. This section outlines the structure of the remainder of this cumulative dissertation, providing an overview of each chapter and explaining how they collectively address the overarching research question of 'How can SPIs be enhanced to foster just climate actions?' [16]. Table 1 provides an overview of the publication details of the chapters of this cumulative dissertation.

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[15] Accessible under Wagner, N. (2024a). Meta Data from Interviews Urban Climate Action Plan Research in Accra, Sao Paulo, Bonn and Ahmedabad [Dataset]. bonndata. https://doi.org/10.60507/FK2/9NQUFP
Wagner, N. (2024b). Metadata for Interviews on the IPCC and the UNFCCC [Dataset]. bonndata. https://doi.org/10.60507/FK2/NNSPS6

[16] The chapter summaries here are based on the abstracts of the published versions of these chapters and resemble in parts the English summary

Chapter	Title	Co-Author(s)	Full Citation
Two	Effectiveness factors and impacts on policymaking of science-policy interfaces in the environmental sustainability context	Sara Velander, Lisa Biber-Freudenberger, Thomas Dietz	Wagner, N., Velander, S., Biber-Freudenberger, L., & Dietz, T. (2023). Effectiveness factors and impacts on policymaking of science-policy interfaces in the environmental sustainability context. *Environmental Science & Policy*, *140*, 56–67. https://doi.org/10.1016/j.envsci.2022.11.008
Three	More than policy neutral: Justifying the power of science-policy interfaces through legitimacy	Simo Sarkki, Thomas Dietz	Wagner, N., Sarkki, S., & Dietz, T. (2024). More than policy neutral: Justifying the power of science-policy interfaces through legitimacy. *Earth System Governance*, 21, 100219. https://doi.org/10.1016/j.esg.2024.100219
Four	How Legitimate Are Urban Climate Planning Processes? A Comparative Assessment of Accra, Ahmedabad, Bonn and São Paulo	Minal Pathak	Wagner, N., & Pathak, M. (2025). How legitimate are urban climate planning processes? A comparative assessment of Accra, Ahmedabad, Bonn and São Paulo. *Environmental Research Communications*, 7(1), 015021. https://doi.org/10.1088/2515-7620/ada7cc
Five	Unlearning Modernity? A Critical Examination of the Intergovernmental Panel on Climate Change (IPCC)	Anna-Katharina Hornidge	Wagner, N., & Hornidge, A.-K. (2025). Unlearning modernity? A critical examination of the Intergovernmental Panel on Climate Change (IPCC). *Climatic Change*, 178(2), 32. https://doi.org/10.1007/s10584-025-03866-y

Table 1: Overview of papers included as publications in this dissertation

In continuation of the introduction, Chapter 2 lays the foundation for the dissertation through a systematic literature review of SPIs in the context of environmental sustainability. This review synthesises existing knowledge about SPI types, effectiveness factors, and their impacts on policymaking. It reveals not only dominant trends in the literature but also identifies gaps in understanding how SPIs can effectively foster change. The chapter highlights how the literature underscores the importance of stakeholder participation, diverse expert backgrounds, interdisciplinarity, and effective communication of complexity as key factors enabling SPIs to impact policymaking, pointing to the need for SPIs to move from the linear towards the co-production model. By pointing to different effectiveness factors of SPIs found in the literature, this chapter sets the stage for examining how legitimacy can further strengthen SPIs' capacity to advance just climate actions.

Building on these insights, Chapter 3 shifts the focus from effectiveness to legitimacy, developing a theoretical framework that considers the input, throughput, and output dimensions of SPI legitimacy. In this chapter it is argued that SPI legitimacy can be used to justify the power of SPIs, acknowledging that SPIs are more than apolitical and policy-neutral entities. The framework identifies 12 criteria of SPI legitimacy across three dimensions: input legitimacy (inclusivity, consideration of multiple knowledge systems, and transdisciplinarity), throughput legitimacy (process accessibility, transparency, reflexivity, conflict management, and accountability), and output legitimacy (efficacy, accessibility, understandability,

and dissemination). By advancing this framework, this chapter underscores how legitimacy can enhance SPIs' role in addressing the justice challenges posed by climate change.

Chapter 4 applies this framework empirically, examining how legitimacy manifests in the creation of UCAPs across Accra (Ghana), Bonn (Germany), São Paulo (Brazil), and Ahmedabad (India). Through an analysis of 72 semi-structured interviews and complementary document analysis, the study conceptualizes different phases of UCAP creation processes and assesses their quality using the framework of input, throughput, and output legitimacy developed in Chapter 3. The chapter highlights the crucial role city networks play in designing and funding these processes and reveals significant differences in the level of co-production, transparency, accessibility, and substantive participation across the case studies. Based on these findings, this chapter provides actionable insights for creating legitimate and impactful UCAPs, ultimately promoting more just urban climate actions.

Moving from the local to the international level, Chapter 5 takes a critical perspective on the IPCC as an example of one of the most prominent SPIs. It examines how modernist logics shape the IPCC's work and identifies pathways for unlearning these logics. Through an inductive-deductive qualitative methodology, including semi-structured interviews with IPCC authors and policymakers at international climate conferences, this chapter finds the IPCC to be situated in a tension field between modernity and unlearning. It identifies emergent tendencies within the IPCC towards broadening disciplinary diversity, incorporating alternative epistemologies like Indigenous knowledge, and fostering co-productive collaborations between scientists and policymakers. These nascent 'unlearning' efforts signal cracks in modernity's edifice, though limitations and potential risks caution against overstatement. These shifts indicate potential pathways for enhancing the IPCC's legitimacy, aligning it more closely with principles of justice and inclusivity in climate action.

The dissertation concludes by synthesising findings from the previous chapters arguing for LKPC enhancing the ability of SPIs to foster more effective and just climate actions. It characterises LKPC relative to the linear and the standard co-production model and points to its epistemic and participatory benefits while highlighting challenges and opportunities for implementation. After having argued for LKPC, the conclusion continues by situating this research into its own framework, critically reflecting upon the challenges in applying LKPC. In continuation, the conclusion offers reflections on how the dissertation has shaped me as a researcher and potentially my surroundings, indicates the academic contributions and contributions beyond the academic realm of this dissertation. It concludes with recommendations for future research directions and practical applications of the LKPC framework in various contexts of climate governance.

CHAPTER 2: SPI EFFECTIVENESS

2. Effectiveness Factors and Impacts on Policymaking of Science-Policy Interfaces in the Environmental Sustainability Context[17]

Chapter Summary

Organizations connecting science and policy, referred to as science-policy interfaces, aim to support policymakers with decision-relevant knowledge, scientific findings, and co-production processes. Given the rising significance of the role of evidence in decision-making in a world dealing with complex problems, a proliferation of literature has developed theories on the effectiveness of such interfaces. While there are studies providing evidence of these interfaces influencing policy, there is limited understanding of the comprehensive range of impacts on policies among multiple science-policy interfaces. Through a systematic review we analysed how 69 research articles investigated structured science-policy interfaces related to environmental sustainability, organizing their types, effectiveness factors, outputs and related impacts on policymaking. We found a majority of the studies focused on global expert groups generating assessments leading to policy formulation and agenda setting, driven by social learning among policymakers. Most references regarding factors enabling impacts on policymaking of science-policy interfaces were found with regards to stakeholder participation, diverse background of experts, interdisciplinarity, and the communication of complexity. Further research is needed to explore the fuzzy boundary between science and policy among different types and models of science-policy interfaces, the interdependencies between effectiveness factors, and the exogenous forces influencing the relationship between SPI outputs and impacts on policymaking. By synthesizing the impacts on policymaking and associated factors of science-policy interfaces found in the literature, our review harmonizes the observations made by scholars on the effectiveness of SPIs in impacting sustainable development policies.

2.1 Introduction

It has been argued that effective policies for reducing biodiversity loss, desertification, and climate change, must be based on the best available knowledge (Balvanera et al., 2020; Jabbour & Flachsland, 2017; Matsumoto et al., 2020; Young et al., 2013). Organizations connecting science and policy, referred to as science-policy interfaces (SPIs), are crucial in their support to decision-makers with relevant knowledge and scientific findings (Balvanera et al., 2020; Neßhöver et al., 2013; van den Hove, 2007). Furthermore, it is argued that SPIs are needed „for a broader and more salient range of knowledges to be produced, exchanged and taken into account in decision-making processes, and to bring about changes in awareness and behavior relating to the societal issue in question" (Young et al., 2013, p.13). Given the rising significance of scientific knowledge for decision-making in a world dealing with complex problems, literature on science-policy interactions proliferated. Initial articles discussed SPIs through the efforts of Global Environmental Assessments (GEAs) underpinned by the field of Science and Technology Studies (STS) and knowledge utilization in Policy Studies. With more than 140 GEAs published in the last 50 years, many of the studies focused on their evolution from being problem- to solution-oriented (de Pryck & Wanneau, 2017; Kowarsch et al., 2017; Maas et al., 2021; Pereira et al., 2021) and their association with multilateral environmental regimes since the Stockholm Conference in 1972 (Jabbour & Flachsland, 2017; UN, 2015; R. T. Watson, 2005).

The literature relevant to SPIs and GEAs provides multiple definitions and typologies on SPIs, with many scholars defining them as large-scale social processes, boundary organizations or multi-stakeholder knowledge platforms where several experts „convene to interpret, deliberate and synthesize existing scientific knowledge on complex environmental issues with a view to inform public policy" (Kowarsch & Jabbour, 2017; Pereira et al., 2021; Sarkki et al., 2020; van den Hove, 2007). We narrow our focus to the definition of SPIs as structured platforms that arrange co-production processes, often resulting in the production of scientific assessments, such as GEAs. The Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), for example, are two well-known structured SPIs at the global level.

SPIs aim at providing policymakers with the best available knowledge on relevant policy issues. Much of the recent literature assesses the ability of SPIs to be effective, hence, impacting policymaking, which are expected to motivate further changes in environmental management and societal behavior. As of now, the majority of the related literature has focused on how different properties of the institutional design of SPIs explain the variation in SPIs effectively influencing policy (Haas, 2017, p.221). These studies fill a crucial knowledge gap highlighted by Kowarsch & Jabbour, (2017, p. 380) on the importance of „improved understanding of the potential causal influence of solution-oriented GEAs in the evolving governance landscape, resulting from both their processes and outputs." However, in order to capture the 'full picture' of the capacity of SPIs to foster influence on policies, a comprehensive synthesis of the impacts on policymaking of a broad array of environmental SPIs documented by scholars is needed. With the exception of Matsumoto *et. al.* (2020) who reviewed the literature on the outcomes of biodiversity-related SPIs, few

studies have achieved this level of extensive synthesis on the assessed impacts on policymaking among SPIs. Additionally, no recent studies have developed and applied a framework to systematically identify the factors for an SPI to be effective in informing policy.

Through a systematic literature review, we answer how the literature studies the effectiveness factors and impacts on policymaking – specifically policymakers' behavior and policy decisions – of SPIs in the context of environmental sustainability. In detail, we aim to answer the following research questions: What different types of SPIs are discussed in the pertinent literature? Which factors promote or hinder the success of SPIs to impact policymaking? What types of outputs do SPIs produce and what are their related impacts on policymaking?

Organizing the key design features of SPIs identified by the literature to effectively impact political decision-making will contribute to a more nuanced understanding among researchers and practitioners alike of the opportunities and barriers of transforming scientific evidence into concrete action plans across scales. Through this summary, we harmonize the recommendations and observations made by scholars on the effectiveness of SPIs in co-producing and communicating knowledge on environmental sustainability to decision-makers.

2.2 Material and Methods

Review Protocol & Selection Process

This study followed the Preferred Reporting Items for Systematic Review and Meta-Analyses to guide the selection of studies for the systematic literature review on how environmental SPIs impact policies in the environmental sustainability context (Moher et al., 2009). The search terms were created based on a preliminary literature review on the scholarly discourse of SPIs as well as preliminary testing of the search string in the database. The search string[18] was organized into terms for SPIs combined with terms for environmental sustainability and terms for impacts: (1) 'science policy' or 'knowledge platform' or 'boundary organization'; (2) 'environment' OR 'climate' OR 'biodiversity'; and (3) 'outcome' or 'impact' or 'effectiveness'. The literature search was conducted using Web of Science, ScienceDirect, and Google Scholar in the end of August 2021, and the screening for duplicates, and title and abstract screening were completed by two reviewers in September 2021.

Scientific publications, specifically articles and book chapters, were included, while other forms, such as dissertations and grey literature, were excluded. We selected studies published in English and from 1990 onwards using the publication year of the first assessment report of the IPCC as a point of reference. Studies were considered for inclusion if they mentioned an SPI or a related term, impact or a related term, and environmental sustainability or a related term in the title or abstract. During the full-text screening, the

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[18] („science policy" OR „knowledge platform" OR „boundary organization") AND (environment OR climate OR biodiversity) AND (outcome OR impact OR effectiveness)

studies included in the final synthesis were only those that explicitly identified and focused their research on an environmental SPI, demonstrated or discussed the impacts on policymaking of the defined SPI, and were accessible online to the reviewers. This ensured the exclusion of articles discussing informal SPIs such as temporary forums or other one-time activities which were not compatible with our research scope. We excluded articles that did not assess the full extent of SPI impacts on policymaking. The screenings were peer-reviewed with justification provided for the exclusion of any studies.

Study Selection

The online search on the databases yielded 480 studies of which we used 69 studies for further analysis (Figure 2)
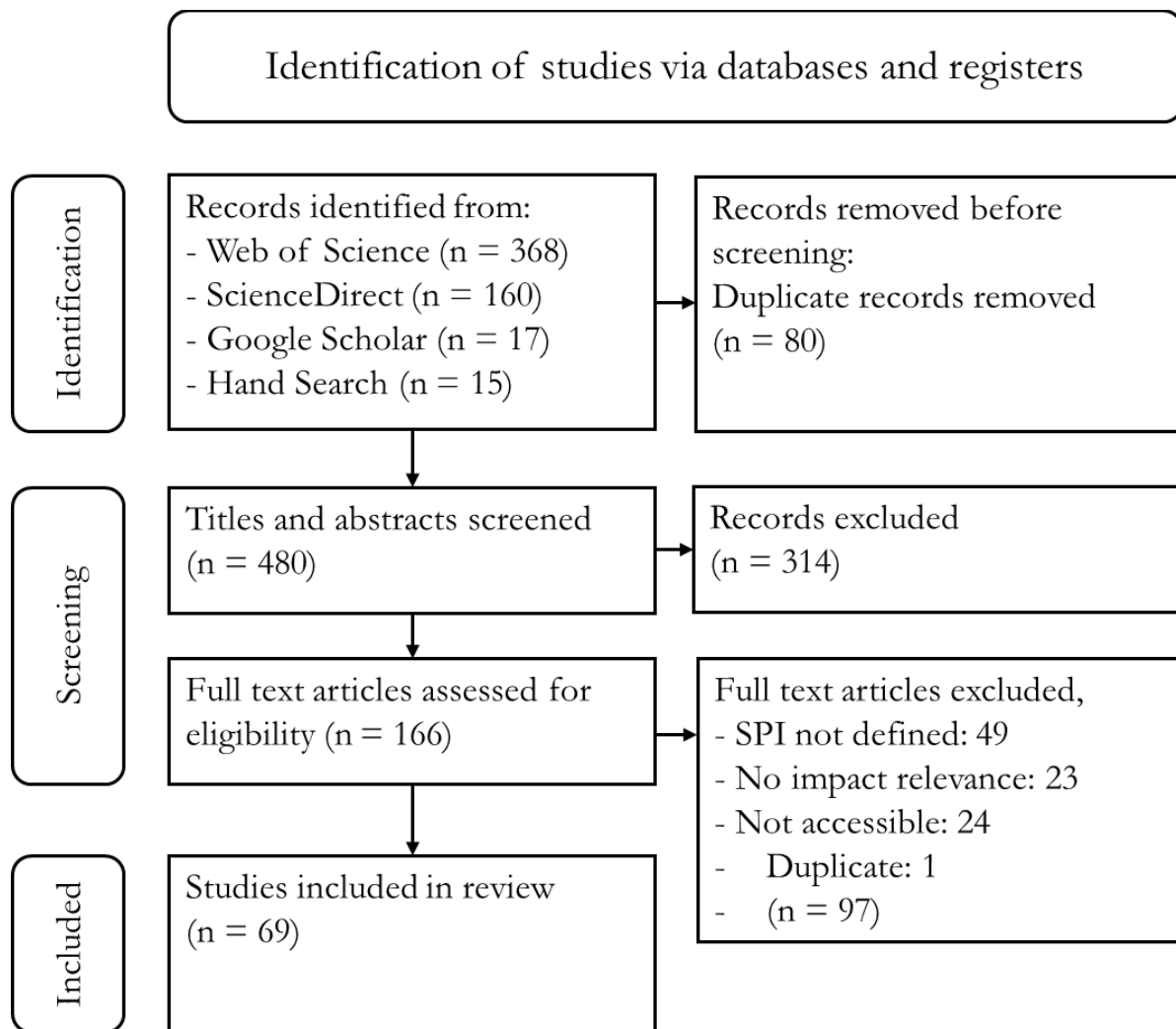
Figure 2: PRISMA Flow Chart of the Study

Synthesis of Results

The studies were analyzed according to a conceptual framework presented below. During the data extraction we recorded the methodological approach the studies used to evaluate SPIs, the name and description of SPIs, and the level and type of SPI. We also assessed whether and how articles discussed the outputs, effectiveness factors, and impacts on policymaking of SPIs. The categories for these components were both inductively and deductively identified, with a few sub-categories of effectiveness factors pre-defined

according to previous literature (Matsumoto et al., 2020; Sarkki et al., 2020). The effectiveness factors were further characterized when data was extracted, indicating whether an article mentioned the presence of an SPI effectiveness factor promoting impacts on policymaking, the absence of an effectiveness factor hindering impacts on policymaking, or the presence of an effectiveness factor hindering impacts on policymaking. We also added the option of whether an article mentioned the SPI effectiveness factor neither promoting nor hindering the generation of impacts on policymaking.

The quantitative data generated by this study was complemented by qualitative data analyzed for semantic keywords providing insights on the different dimensions of SPIs, which we transformed into a few overarching themes (Clarke & Braun, 2017).

2.3 Conceptual Framework

We developed a conceptual framework based on a preliminary literature review, which we used to review and code the articles selected for the systematic literature review. This conceptual framework shows (1) the different types and levels of SPIs, (2) SPI outputs, (3) suggests a preliminary categorization of factors endogenous and exogenous to SPIs contributing to the effectiveness of SPIs, and (4) conceptualizes impacts on policymaking (Figure 3).
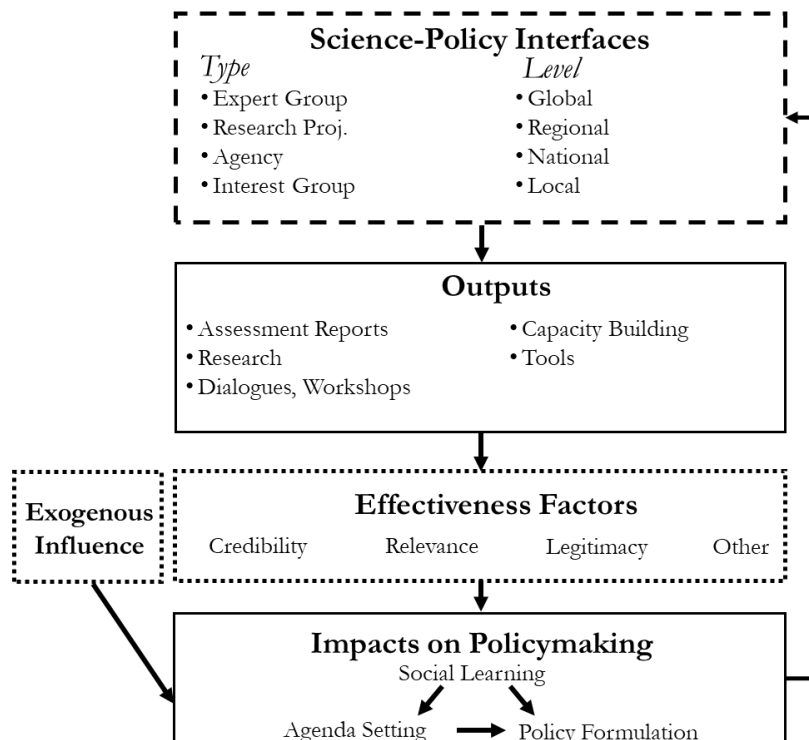
Figure 3: Conceptual framework of the study[19].

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[19] It shows the impact pathway of different types of SPIs (expert groups, research projects, agencies and interest groups). The box of SPIs is in dotted lines to indicate the fuzziness of determining the boundary between science and policy. SPIs produce outputs, the tangible products emerging from the knowledge co-production processes (e.g.

SPI Definition, Types and Levels

While SPIs are often broadly understood as both recurring and irregular social processes (Kowarsch & Jabbour, 2017; van den Hove, 2007), this paper focuses on SPI organizations, defined as purposively set up platforms for the exchange of evidence between knowledge-producing and policymaking stakeholders (Sarkki et al., 2020). To classify this wide range of SPIs, we adopted a typology of SPIs developed by Timaeus et al. (2011). Based on empirical and theoretical grounding, this typology identifies four distinct SPI types, namely 'expert groups', 'research projects', 'agencies' and 'interest groups'. The SPI types are differentiated based on the presence of a political mandate, temporal scale, functions and organizational structure unique to each type (Timaeus et al., 2011).

'Expert groups' consist of policymakers and scientists who are not personally affiliated with the SPI, often mandated by a political body e.g. IPCC and IPBES. These groups can be short- or long-lived and the main function is to synthesize existing knowledge. 'Research projects' are science-led projects embedded in a research institution often funded by a governmental body (e.g. ministry of environment) with a limited duration and containing transdisciplinary characteristics. 'Agencies' are SPIs integrated within or affiliated with a political organization or government body, conducting research or systematically synthesizing scientific literature for specific purposes. Finally, an 'interest group' is defined as an SPI integrated within a non-governmental or international organization centered on a specific issue or advocating for a cause in the long term.

While this condensed list of SPI categories may exclude several important forms of science-policy initiatives, like actor coalitions, international organizations and Multilateral Environmental Agreements (UNEP, 2021), the typology is still comprehensive by highlighting lesser known, formalized SPIs across multiple scales. Needless to say, this typology of SPIs is not exhaustive but rather illustrative. Without strict boundaries between the four SPI types, it can be difficult making a clear assignment of an SPI to a type.

Outputs of SPIs

The main purpose of SPIs is to create impacts on policymaking for society through the outputs they generate. In this study, outputs refer to the tangible products of SPIs emerging from co-production processes, such as policy briefs, reports, assessments, workshops, dialogues and presentations which synthesize the evidence on a topic relevant to policy (Sarkki et al., 2015; Young et al., 2013). In the literature on boundary organizations, outputs in this context are often referred to as 'boundary objects' (Hoppe et al., 2013) or 'boundary outputs' (Guston et al., 2000) which is the key activity scientists and policymakers coordinate on, such as the summary for policymakers of SPI reports, models, and indicator systems. These

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assessments). Effectiveness factors –categorized by credibility, relevance, legitimacy, and other – determine the effectiveness of the SPI in creating impacts on policymaking. Impacts in policymaking are generated through social learning where SPI outputs increase the understanding of policymakers on particular issues, hence, supporting policy changes such as agenda setting and policy formulation. We acknowledge that next to SPI outputs there are other factors exogenous to the SPI that contribute to impacts on policymaking. Knowledge on the SPI impacts on policymaking feed back into SPIs indicated with the arrow linking both boxes.

final products of SPIs are, therefore, a crucial component in our framework as their utility among policymakers has been the focal interest in the relevant literature.

We recognize that some literature with more inclusive definitions of SPIs (Gupta, 2012) considers large-scale processes of generating outputs, such as the Global Environment Outlook (GEO), as an SPI. Understanding SPIs as purposively set up platforms we rather consider UNEP or the designated department preparing the GEO assessment as the SPI. While acknowledging the important role of processes, we focus with our definition rather on the institutional set-up of SPIs instead of the informal processes such as occasional discussions between scientists and policymakers leading to the tangible products of SPIs.

Effectiveness Factors and Exogenous Influence on SPIs

The successful generation of impacts on policymaking is defined as effectiveness of SPIs. The literature highlights different factors associated with the inputs to the institutional design of an SPI contributing to its effectiveness. In the literature, these factors are often categorized into the criteria of 'Credibility, Relevance, and Legitimacy' (CRELE) based on theory by Cash et al. (2003). Credibility is understood as the scientific adequacy measured by multiple criteria including reliability, validity, and adequacy. Sarkki et al. (2014) defined three main factors associated with credibility: communication of uncertainties, quality assessment, and meeting the supply of knowledge. Relevance, or salience, refers to the usefulness of information for policymakers and societal needs, which is encapsulated by these factors: timeliness, simplicity, and meeting the demand for knowledge (Sarkki et al., 2014). Finally, legitimacy relates to „issues of ethics and fairness in knowledge generation and knowledge exchange" (Ojanen et al., 2021, p.11), which includes factors of consensus, wide participation, and a range of views (Sarkki et al., 2014). Factors unrelated to CRELE are categorized as 'other' e.g. partnerships or collaboration between SPIs and other like-minded organizations. This latter category contributes to scholarly discourse criticizing CRELE as insufficient for determining the effectiveness of SPIs (Dunn & Laing, 2017; Hansson & Polk, 2018). We incorporated CRELE into our framework as it is the predominantly accepted metric on SPI effectiveness in the literature. However, we recognize the critique of CRELE in the discussion thus, confirming its flaws when analyzing a diverse range of SPIs.

Crucially, we envision that factors endogenous and exogenous to the SPI determine the ability of SPI outputs to create impacts, i.e. policy changes, shaping a long causal pathway made up of multiple actors and factors, including the policy setting and third-party interests (Rudd, 2011; UNEP, 2021; Young, Watt, van den Hove, et al., 2013). Effectiveness factors and exogenous influence are, therefore, placed between these two components in Figure 2.

SPI Impacts on Policymaking

Impacts on policymaking are the substantive influences of SPI outputs on the behavior and understanding of policymakers and related political decisions. The first category of impacts on policymaking is social learning which represents changes to the policymaker's understanding of an issue based on knowledge gained and lessons learned from SPI outputs. During instances of social learning, complexities of a problem

are revealed and clarified, bridging the communication divide between 'experts' and 'non-experts' through information exchange (Diver, 2017). Rudd (2011) and Young *et al.* (2013, p.12) describe how impacts on policymaking are dependent on outputs leading to „SPI participants, audiences and the wider public learning and changing their thinking" of a phenomenon, ultimately resulting in changes in the behavior of policymaker and the policy they formulate. Thus, social learning is crucial in its contribution to supporting policy change. We recognize that the use of these knowledge products is more of a process rather than a distinct event (Radaelli, 1995, p. 162).

The second impact category represents the contribution of SPI outputs to direct changes or reforms in political decisions, i.e. agenda setting and policy formulation (Dinesh et al., 2021; Matsumoto et al., 2020; Tinch et al., 2018). Agenda setting is when „problems come to the attention of governments" leading to problem definition once added to governmental agendas (Gauvin, 2012, p.152). Policy formulation refers to when policymakers generate various policy options to address an identified problem (Gauvin, 2012). Ultimately, knowledge on relevant policy changes feeds back into the SPI through mandates, funding, and knowledge demand, indicated by the arrow from 'impacts' to 'SPI' in Figure 2.

2.4 Results

Findings on SPI Types and Themes

While we searched for literature published from 1990, the majority of the 69 articles included in this review were published in the last five years indicating a rise in the importance of analyzing the effectiveness of SPIs. The included 69 articles analyzed a total of 93 separate case studies of SPIs. We calculated this number because 11 of the 69 articles were comparative papers analyzing multiple SPIs, with Hanger et al. (2013), for instance, analyzing six different SPIs.

The majority of studies investigated SPIs at the global level, while non-global SPIs observed were mainly located in Europe and North America. Most SPIs were identified as expert groups with one-third of the case studies analyzing the IPBES and the IPCC. SPIs identified as research projects include, for instance, the Natural Environment Research Council Knowledge Exchange Program on Sustainable Food Production (L. V. Dicks et al., 2013). An example of one of the SPIs classified as an interest group is the Brazilian Platform on Biodiversity and Ecosystem Services, which has an explicit interest in halting biodiversity loss (Scarano *et al.*, 2019). The Spanish Climate Change Office was classified as an agency because it is a coordinating entity within the Ministry of Environment and the National Climate Council, a participatory body with a wide range of stakeholders represented (Hanger et al., 2013). Aside from the climate and biodiversity focus, the selected SPI cases covered an array of themes, including disaster risk reduction, desertification, soil, marine conservation, water resources management, agriculture, and forest science.

Category	Characteristic	Number of SPI cases
Level of SPI	Global	48
	Regional	17
	National	17
	Local	11
Regional origins of non-global SPIs	Europe	23
	South America	2
	Oceania	4
	Africa	3
	Asia	1
	North America	8
	Arctic	3
	Antarctica	1
Type of SPI	Expert Groups	55
	Research Project	14
	Agency	18
	Interest Group	6
SPIs identified	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)	18
	The Intergovernmental Panel on Climate Change (IPCC)	14
	Other (listed in supplementary material)	63

Table 2: Summary of the basic characteristics of the 93 individual cases of SPIs

Findings on SPI Outputs
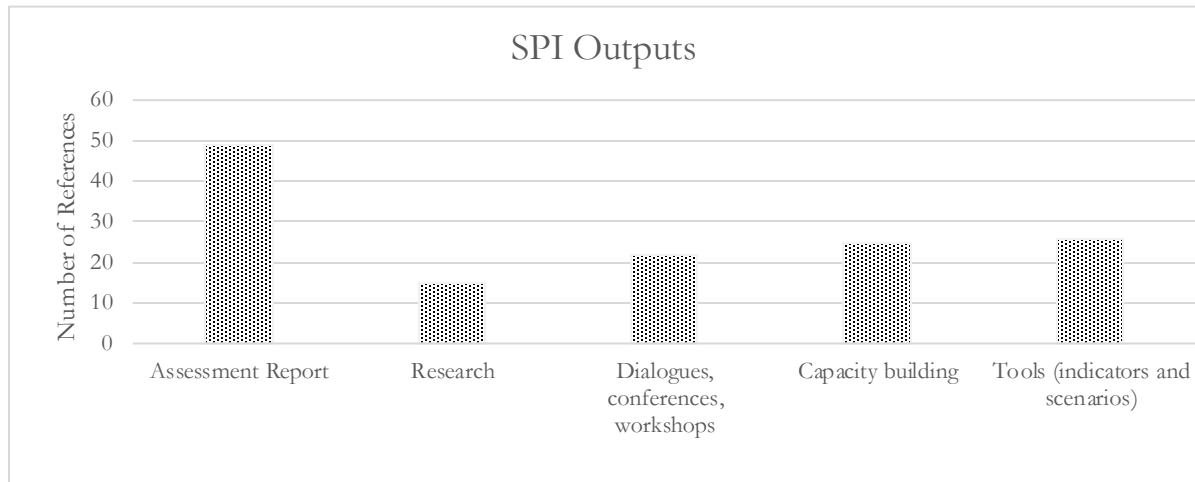
Figure 4: Proportion of SPI output types

We found most studies focused their analysis on the assessment reports generated by SPIs (36%). Various types of assessment reports across different scales are reported in the studies, such as the regional reports by the IPCC (Sitas et al., 2019) and the local coastal vulnerability assessments by Ocean Watch (Shaw *et al.,* 2013). Scholars described these assessments as a consolidation and synthesis of existing, peer-reviewed published literature accompanied by evidence-based recommendations for policymakers (Hughes, 2015; Humphreys, 2009; Shaw et al., 2013).

Aside from assessments, other studies found that SPIs generate tools for policymakers including scenarios (Kirchhoff *et al.,* 2015), indicators (Aitsi-Selmi et al., 2016), software programs (Ziaja, 2019), computer models (Chapple et al., 2011), management systems and gear technology (Shaw *et al.*, 2013), report cards (Frost et al., 2017), networks (de Santo, 2018), and maps (de Dona, 2021). Several scholars described how tools and capacity building greatly contributed to strengthened understanding among policymakers, indicating how tools could be an important driver of social learning. Capacity building was mentioned by scholars when discussing how SPIs organized trainings in knowledge co-production for participants, such as, the fellowship program in IPBES (Gustafsson *et al.*, 2020; Kelemen *et al.*, 2021) and skill-sharing in climate brokering in the Great Lakes Integrated Sciences and Assessment (Kirchhoff *et al.*, 2015).

Findings on SPI Effectiveness factors

We identified a total of 424 references to effectiveness factors in the texts distributed across 15 categories which were further categorized according to credibility, relevance, legitimacy, and others (Table 3). Most of the factors identified in the included studies were associated with the institutional design, encompassing the procedures, rules, and processes for creating outputs within SPIs, and were primarily found to promote impacts on policymaking.

	Promoting impact	%	Lacking to promote impact	%	Hindering impact	%	Neither promoting nor hindering impact	%	Total
Interdisciplinarity	29	72,50	10	25,00	0	0,00	1	2,50	40
complexity/uncertainty communicated	15	37,50	21	52,50	2	5,00	2	5,00	40
scientific validity	14	73,68	5	26,32	0	0,00	0	0,00	19
independence of scientific and political processes	16	53,33	10	33,33	3	10,00	1	3,33	30
Credibility Total	**74**	**57,36**	**46**	**35,66**	**5**	**3,88**	**4**	**3,10**	**129**
multiscale engagement with policy makers/practitioners	16	64,00	7	28,00	1	4,00	1	4,00	25
alignment demand and supply for knowledge	27	64,29	12	28,57	1	2,38	2	4,76	42
Relevance Total	**43**	**64,18**	**19**	**28,36**	**2**	**2,99**	**3**	**4,48**	**67**
political support	10	58,82	3	17,65	3	17,65	1	5,88	17
inclusiveness/participation of stakeholders	25	55,56	9	20,00	3	6,67	8	17,78	45
inclusion of diverse knowledge systems	12	48,00	12	48,00	1	4,00	0	0,00	25
transparency and accountability	13	72,22	4	22,22	1	5,56	0	0,00	18
Diverse background of experts (regions, gender)	16	69,57	7	30,43	0	0,00	0	0,00	23
Legitimacy Total	**76**	**59,38**	**35**	**27,34**	**8**	**6,25**	**9**	**7,03**	**128**
linkages with other SPIs	25	83,33	4	13,33	0	0,00	1	3,33	30
Key agents and personal connections	24	100,00	0	0,00	0	0,00	0	0,00	24
iterativity (learning and reflexivity)	19	73,08	3	11,54	0	0,00	4	15,38	26
resources (time and money)	8	40,00	10	50,00	0	0,00	2	10,00	20
Other Total	**76**	**76,00**	**17**	**17,00**	**0**	**0,00**	**7**	**7,00**	**100**
Total	**269**	**63,44**	**117**	**27,59**	**15**	**3,54**	**23**	**5,42**	**424**

Table 3: The frequency of references on each effectiveness factor
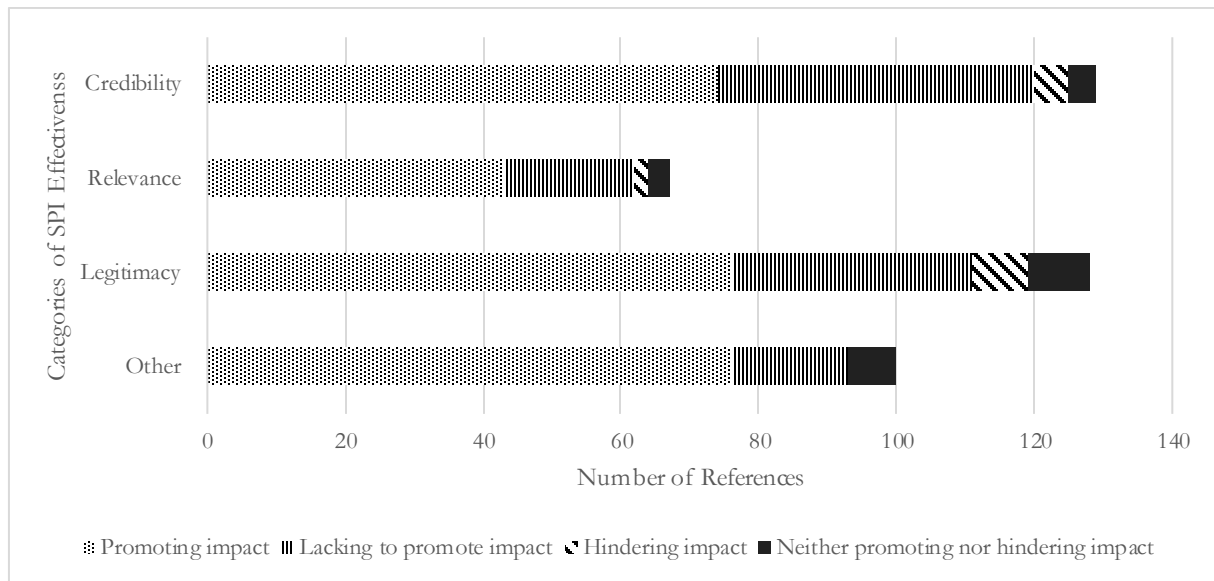
Figure 5: The distribution of references in the studies to the SPI effectiveness factors

Credibility

Among the four effectiveness factors related to credibility, the communication of complexity and uncertainty was found to significantly promote impacts on policymaking. In cases where this factor was absent and hindering impacts, scholars found that diverse anthropogenic causes of environmental issues were not specified in reports (Tynkkynen, 2015). We observed a trend of studies highlighting the consideration of socioeconomic factors at multiple scales and making confidence assessments to overcome challenges of communicating uncertainty and complexity (Frost et al., 2017; Nilsson, 2009).

Two-thirds of references indicated the benefits of scientific validity. Authors cited consensus-building (Andresen et al., 2018; Humphreys, 2009; Koetz et al., 2012), peer review processes (Frost et al., 2017), and the nomination of diverse, relevant, and qualified experts (Vohland *et al.*, 2011; Shaw *et al.,* 2013; Kovacs and Pataki, 2016) as key components for promoting the scientific validity of an SPI.

Many studies highlighted the importance of interdisciplinarity for creating impacts on policymaking, stating that „expertise in the form of interdisciplinary experience also helps the broker interact in the settings of both producers and users of information" (Guido *et al.*, 2016, p.294). The absence of interdisciplinarity was found to hinder the effectiveness of SPIs when the SPI was solely composed of economists or natural scientists, rather than social scientists, political scientists, geographers, and sociologists (Borie et al., 2021; de Santo, 2018; Gustafsson et al., 2020).

We also found frequent references to the independence of scientific and political processes which aims to prevent undue influence on SPI outputs. In a study on the 'Scientific Committee of the International Whaling Commission', Andresen et al. (2018) found that science was politicized and, thus, hindered its influence on policies. Most authors, therefore, advocated for the independence of science observing that it is vital for providing credible, evidence-based information (Frost et al., 2017). On the other hand, we found two articles underscoring the need for a „separation and integration" balance between science and policy in

SPIs (Humphreys, 2009, p.170) by maintaining autonomy in knowledge production and integrating the two communities of actors when creating actionable outputs (Andresen et al., 2018).

Relevance

We found that multiscale engagement with policymakers promote impacts on policymaking through multiscale assessments (Borie et al., 2021), the establishment of informal networks and advisory groups (Sarkki et al., 2020), national consultations (Tynkkynen, 2015), and regional workshops. Tàbara et al. (2017) demonstrated the consequences when this factor is absent with the IPCC not specifying local climate change impacts explaining the limited use of IPCC reports in Spain. Kelemen *et al.* (2021), however, found that multiscale engagement led to lengthier and legally-complicated procedures which hindered effectiveness.

The alignment of demand and supply for knowledge between scientists and policymakers was considered mostly as an opportunity for creating impacts on policymaking, for instance, through jointly created research, policy goals, mandates, and policy-specific tools (Aitsi-Selmi et al., 2016; Becsi et al., 2020; Borie et al., 2021). In the cases where misalignment hindered impacts on policymaking, scholars found it was mainly due to scientists not knowing the policy process or policy actors unfamiliar with the generation of scientific results (Chapple et al., 2011; Kelemen et al., 2021).

Legitimacy

Inclusiveness and participation of non-scientific and non-policy stakeholders, referring to the participation of NGOs, research organizations, Indigenous groups, local communities, and the private sector within SPIs, were found to promote impacts on policymaking in most SPI cases. However, some studies highlighted the challenges caused by lengthy multistakeholder processes addressing urgent problems, such as the costs incurred by the delays of action (Andresen et al., 2018; Ruckelshaus et al., 2020; Spence, 2017).

The 'inclusion of diverse knowledge systems' was cited in cases where local and Indigenous knowledge was included in assessments (Borie et al., 2021; Savaresi & Chiarolla, 2015; Vadrot, 2020). For example, in the Arctic Climate Impact Assessment, Nilsson (2009) found significant integration of Indigenous observations and perspectives, which increased its utility for Indigenous peoples. Moreover, IPCC assessments are often criticized by authors for their lack of diverse epistemologies (S. Beck & Oomen, 2021; H. Hughes, 2015).

The diversity of backgrounds refers to achieving gender and regional balance in SPI membership. Many scholars found that SPIs continued to be dominated by scientists from the Global North (S. Beck, 2011; Hulme & Mahony, 2010; Koetz et al., 2012; Lee et al., 2014). Studies on expert groups also emphasized the „under-representation of Indigenous and local community experts and an over-representation of academic experts" (Hakkarainen et al., 2020; Savaresi & Chiarolla, 2015).

While regarded as important for enabling impacts on policymaking, transparency, accountability and political support were the least cited effectiveness factors in the SPI cases. Many studies found a lack of transparency hindering the effectiveness of SPIs, like the IPCC after facing public scrutiny (Andresen et al., 2018; S. Beck & Oomen, 2021), while other studies found political support leading to impacts on policymaking through mandates or governmental approval of SPI outputs (Andresen et al., 2018; Borie et

al., 2020; S. Koch, 2018). Nonetheless, scholars also found climate sceptics and actors with strategic interests „undermining the scientific integrity" of SPIs (Hughes, 2015, p.87; Dicks *et al.*, 2016; Fawkes and Cummins, 2019).

Other Effectiveness Factors

The most cited effectiveness factor unrelated to any of the CRELE categories was the linkages between SPIs which scholars claimed to contribute to the advancement of organizational missions, distribution of tasks, social learning, shared resources, access to a larger network of stakeholders and information, and the co-development of robust solutions (Kettle and Trainor, 2015; Kirchhoff *et al.,* 2015; Dicks *et al.*, 2016; Frost *et al.*, 2017; Ziaja, 2019; Kelemen *et al.*, 2021).

Key agents connecting information between knowledge-holders and policymakers also helped create impacts on policymaking. de Dona (2021), for instance, found that the chair of the Intergovernmental Technical Panel on Soils was pushing the SPI process. Other SPI cases found that personal policy networks among SPI experts, intermediaries and focal points were crucial for the effective communication of results (Laes and Couder, 2014; Riousset, *et al.,* 2017; Spence, 2017; Tàbara, *et al.,* 2017).

'Iterativity' which addresses the dynamism needed for SPIs to be effective and linked to learning and reflexivity (Sarkki et al., 2015) was considered an opportunity for SPIs in promoting impacts on policymaking. Scholars underscored the need for a „continuous process of evaluation, reflection, learning and adapting" through consultations (Colavito et al., 2019) and feedback surveys (Shaw et al., 2013) to increase the influence of SPI activities (Kettle & Trainor, 2015).

Monetary resources and time are important factors contributing to the effectiveness of SPIs. For instance, Ziaja (2019, p.843) emphasized how funding agencies „fostered the growth of knowledge networks and person-to-person communication" leading to the overall success of the SPI. In 10 cases, scholars found that insufficient funds, unstable internet access, and low staff capacity limited the stakeholder participation process, interdisciplinarity, and relationship-building in an SPI (Kettle and Trainor, 2015; Savaresi and Chiarolla, 2015; Beaven *et al.*, 2017; Oubenal *et al.,* 2017; Colavito *et al.*, 2019).

Findings on the Impacts on Policymaking of SPIs

Figure 6: The frequency of references to different types of impacts on policymaking.

Regarding overall impacts on policymaking, we found social learning mentioned most frequently in the included articles (n=53) highlighting the importance of how SPI outputs changed the understanding and increased the awareness of policymakers and relevant stakeholders of SPIs on environmental sustainability issues. Tàbara et al. (2017, p.32) cited that social learning is rooted in the mandate of many SPIs being policy informative rather than policy prescriptive. Therefore, SPI outputs, like the IPCC reports, are regarded as 'reference books' instead of 'manuals for action' (Tàbara *et al.,* 2017). However, our framework considers that changing the understanding of the policymaker leads to direct policy changes. Hence, by being policy informative SPIs are facilitating a transfer of knowledge on new concepts to the policy arena, thereby, elevating and clarifying certain issues to support policy change.

Among the changes to political decisions, policy formulation was the most cited stage of the policy cycle where SPI outputs had a more notable impact. For instance, Hughes *et al.* (2018) found that the reports of the Scientific Committee on Antarctic Research (SCAR) directly contributed to the formulation of treaties, policies and work programs in Antarctica while the IPBES thematic assessment on pollinators led to the development of the EU pollinators initiative and the National Pollinator Health Strategy in the US (Ruckelshaus et al., 2020). Scholars also found that SPIs helped place certain issues on the agenda of policymakers, such as the use by decision-makers of the UN regular process assessments to „motivate more policies on marine plastics" (Fawkes and Cummins, 2019).

2.5 Discussion

In this section, and summarized in Figure 6, we highlight the key findings from a systematic literature review of 69 peer-reviewed scientific articles on the impacts on policymaking of SPIs along with identifying the main knowledge gaps according to our conceptual framework. While the framework simplifies the complex

relations between an SPI and its pathway towards impacting policymaking, we recognize the multitude of interacting forces and actors that shape science-policy processes in an iterative and complex manner (Sarkki et al., 2015; UNEP, 2021).
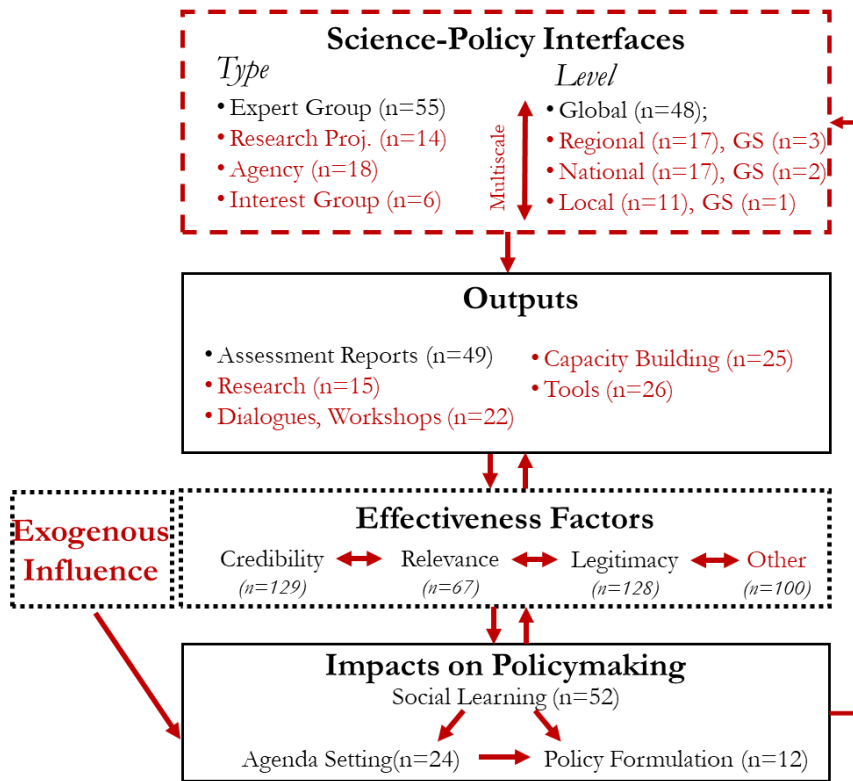
Figure 7: Key findings of the systematic literature review embedded in the conceptual framework[20]

At The Fuzzy Boundary Between Science and Policy: Linear Vs. Co-Production Models

The 69 articles included 93 case studies of SPIs where we found a majority of SPIs classified as expert groups which are often institutionally designed according to the linear model of science-policy interactions. The main idea of this linear model is that science and policymaking should be separate processes with „science speaking truth to power" (Hoppe, 2005; de Pryck and Wanneau, 2017; Díaz-Reviriego *et al.*, 2019). Science is considered authoritative to present unchallenged knowledge in this model with SPIs actively pursuing 'boundary work', which emphasizes maintaining the boundaries between science and policy (de

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[20] This Figure highlights the remaining knowledge gaps in red. Initially, it indicates the need for research on SPI types other than expert groups and SPIs located in the Global South (GS). The red arrow in the box on SPIs shows the lack of knowledge on the multiscale interactions of the different SPI types. The red dotted lines surrounding the SPI box indicate the need for research comparing the different models of SPIs (linear and co-production) and their related impacts. The outputs marked in red refer to the need for studies to go beyond assessments and examine other output types. The red arrows between outputs and effectiveness factors and the arrows between effectiveness factors and impacts on policymaking emphasize the difficulty of determining causal links with a multitude of interacting factors driving policymaking, further embodied in the dotted box on 'exogenous influence'. The red arrows between the effectiveness factors indicate the knowledge gap on interactions between them and the red arrow between impacts on policymaking and SPIs highlights the knowledge gap on how impacts on policymaking can be linked back to the SPI.

Pryck & Wanneau, 2017). This active separation between facts and values was highlighted by parts of the literature to promote the effectiveness of SPIs and is exemplified, for instance, by the mission of the IPCC aiming to be policy relevant without being policy prescriptive (S. Beck, 2011). However, based on the IPCC and many other environmental SPIs ultimately aiming to improve socio-economic outcomes (Maas et al., 2021, p. 210), the strict separation of science and policymaking or facts and values is often found to contribute to a significant disconnect between these two communities of actors (Jabbour et al., 2012). To reconcile the boundaries between science and policy, much of the literature conceptualizes SPIs as „social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making" (van den Hove, 2007, p. 815). Common scholarship advocates rethinking the linear understanding of the science and policy interaction in terms of a co-production model (S. Beck, 2011; de Pryck & Wanneau, 2017a; Koetz et al., 2008).

Considering the interaction between science and policy as an iterative, joint co-production process is particularly important for SPIs in the environmental sustainability context. Firstly, environmental issues are characterized by uncertainty, situations where the odds for certain outcomes are unknown, and indeterminacy, conditions where causal links are unknown (Funtowicz and Ravetz, 1993; van den Hove, 2007; Schick, *et al.,* 2017). To address these limits of scientific knowledge concerning environmental issues, the inclusion of moral knowledge through a multi-directional and iterative interaction between policymakers and experts is needed (Wynne, 1992). Secondly, the functions of environmental SPIs are very different today than they were 50 years ago, increasingly focusing on developing solutions instead of describing problems (de Pryck & Wanneau, 2017; Kowarsch et al., 2017; Kowarsch & Jabbour, 2017). Because the development of solutions is inherently normative it requires continuous interactions between science and policy and, hence, the co-production model is more suitable for facing today's challenges (Funtowicz & Ravetz, 1993). The shift in focus of environmental SPIs on solutions can be exemplified by the rise in SPI outputs on mitigation and adaptation solutions to address relative to understanding climate change.

Assessment reports, capacity building, tools as well as dialogues and workshops are the tangible SPI outputs identified in the included studies. With assessment reports being featured the most in the literature and typically exemplifying the linear SPI model, substantial literature has observed a rise in 'assessment fatigue' where policymakers grow tired of reading lengthy assessments, often culminating in less incorporation of scientific findings in policies (Borie et al., 2020; F. R. Scarano et al., 2019). Scholars investigating SPIs are, rather, urging SPI stakeholders to 'go beyond assessments' and produce a diverse, balanced array of outputs, to ensure that knowledge co-produced is actionable for policymakers and practitioners and, hence, lead to impacts on policymaking (Gustafsson, 2018; Maas et al., 2021; Shaw et al., 2013; Spence, 2017). Further research is needed to examine how the processes of different models influence the variety of outputs generated along with the evolution of the literature on the co-production model relative to the linear model to identify trends in reports of SPIs transforming their institutional designs.

Research Needs on SPI Types and Collaboration with an Emphasis in the Global South

To develop and implement solutions for complex environmental sustainability problems, more knowledge on the different types of SPIs and their association with varying models of institutional design is needed given the small number of them classified as interest groups, agencies, and research projects. Additionally, the small number of non-global SPIs investigated indicates the need for more knowledge on different types of SPIs located at different scales to advance understanding on the full scope of SPI types and their distinctive impacts on policy (Hoppe *et al.*, 2013; Ishii and Okubo, 2014; Kelemen *et al.*, 2021). Furthermore, we recognize that the literature needs to assess the ability of SPIs to create impact through the frequency of their interactions across scales and SPI types to identify trends of effective collaboration.

Next to studying the dynamics between different types and levels of SPIs, our systematic literature review points to the necessity of conducting more research on SPIs located in the Global South. Similarly found in Matsumoto *et al.* (2020, p.164), the lack of studies on SPIs in the Global South could be explained by (1) economic priorities to end poverty over funding research and science in developing countries resulting in an absence of SPIs in the Global South , and (2) a lack of awareness of existing SPIs in developing countries leading to less funding in assessing their impacts on policymaking. Funders together with researchers should address this to ensure a geographically complete picture on SPIs and their impacts on policymaking.

Consideration of the Interdependence of Factors and Contexts Making SPIs Effective

In the 69 articles reviewed, we identified 15 factors related to the effectiveness of SPIs mentioned over 400 times. CRELE, as a categorization for these effectiveness factors, was selected when designing the conceptual framework of this study because of its broad recognition in the SPI literature. This is also reflected in our results that indicate around three-quarters of all references were grouped under CRELE. However, with there being one-quarter of references in the text not grouped under CRELE highlights the limits of the renowned framework. Under 'other' we grouped the collaboration between SPIs, the importance of policy networks, resources, and iterativity which are important factors contributing to the success of SPIs achieving impacts on policymaking. Future research could consider alternative, more inclusive ways of grouping effectiveness factors such as the Applicability, Comprehensiveness, Timing and Accessibility (ACTA) framework highlighted by UNDESA (2021).

Iterativity, in particular, was shown to be a key driver of SPI effectiveness (Riousset et al., 2017; Sarkki et al., 2015; R. T. Watson, 2005). These studies emphasize the need for repeated, continuous discussions between scientists and policymakers throughout the co-production process. For example, the Millennium Ecosystem Assessment lacked these fruitful exchanges which ultimately led to the failure of the SPI output in successfully impacting policy (R. Watson, 2012). Iterativity being just one of many important attributes pivotal for the process of generating SPI outputs, indicates the need for further research on the key characteristics of SPI processes that shape outputs and their associated impact on policymaking.

When analyzing effectiveness factors, we also found an interdependency among them. For instance, prioritizing the communication of complexity and uncertainty led to trade-offs with the simplicity and clarity of messages (Sarkki et al., 2014, p.199). The clarity of messages of SPI outputs can as well be reduced by increased participation and the inclusion of diverse knowledge systems as possible contradictions in perspectives need to be described pointing to challenges of the co-production model (Andresen et al., 2018; Lofmarck & Lidskog, 2017). With this study showing that a few factors hinder rather than promote effectiveness of SPIs, future research should systematically evaluate these trade-offs between effectiveness factors and indicate the relative importance of certain factors in specific situations, building on prior studies, such as Sarkki et al. (2014).

Through our review, we found that in each of the 93 case studies of SPIs analyzed a unique set of effectiveness factors have promoted or hindered impacts on policymaking. Hence, we conclude that there is no 'one-size-fits-all' approach for making SPIs effective, and the balance between these factors is considerably context-dependent (Tàbara et al., 2017). Furthermore, we recognize that knowledge gaps on effectiveness factors suitable to specific contexts could be addressed by including relevant grey literature, a primary limitation of our review which only included peer-reviewed articles. Non-academic publications from international organizations, government institutions or NGOs could contain valuable knowledge on SPI effectiveness, particularly tracing policy changes to SPI outputs and associated factors which could enrich the limited database on SPIs.

From SPI Outputs to Impacts on Policymaking: A Difficult Relationship to Establish

A comprehensive analysis of the SPI effectiveness factors would need to account for the multitude of factors, actors, and political institutions exogenous to SPIs (Brachthäuser, 2011; Little, 2012; Nyhlén and Lidén, 2014; UNEP, 2021, p. 18). Previous literature on SPIs has discussed the presence of these exogenous factors to a limited extent, with many commenting on how the political setting and scale of the environmental problem are considerable influences on decision-making (Kieslich & Salles, 2021; Matsumoto et al., 2020; Spence, 2017). Scholars specify some influences exogenous to SPIs including third-party interests, changes in political regimes, organizational culture, values, ethics, financial resources, and catalyzing events (Soomai, 2017; Wall, et al., 2017; Dunn, et al., 2018). SPIs can be successful in making an impact on policymaking by identifying 'policy windows', where public problems perceived with a sense of urgency intersect with a willingness of political actors in implementing a discourse (Lange and Garrelts, 2007).

How do effectiveness factors and exogenous influence impact the ability of SPI outputs to contribute to impacts on policymaking? While our review highlights the importance of social learning, further research is needed to trace this process, identify the means of knowledge transmission, and understand the relative importance of individual effectiveness factors in different stages of the process to understand how SPI outputs impact policymaking. Necessarily, to confront this challenge in future research, addressing the following research questions is a crucial step forward: 1) What is the role of civil society and (social) media

in promoting SPI outputs? 2) To what extent is the comprehensibility of SPI outputs contributing to the ability of SPIs to make an impact on policymaking? 3) How has the discourse changed because of SPI outputs and how does this influence the ability of SPIs to influence policymaking?

Highlighting the knowledge gaps in the literature as summarized in Figure 6, we offer an understanding of how SPIs and related outputs and their impacts on policymaking can be studied to better assess the effectiveness of SPIs. Recognizing that our framework is only one way to understand the relationship between science and policymaking, we are mindful of other approaches to conceptualize the complex cycle in which SPIs impact policymaking in a more co-productive manner. Our framework provides a foundation for future research to build on the burgeoning study of the impacts on policymaking among SPIs, building a path for a comprehensive understanding on the role of SPIs relative to exogenous factors in the social, political, and environmental contexts on policy changes. Such findings could potentially enhance the embeddability of SPIs in the policy arena, providing 'windows of opportunity' for having a tangible impact on policymaking. By carrying a rich knowledge base on the interacting factors impacting political decision-making, SPIs would be able to harness strategies where outputs offer tractable solutions for policymakers, being framed in „specific moments, modes and loci for action" (Jabbour and Hunsberger, 2014; Stirling, 2014, p.7).

2.6 Conclusion and Practical Recommendations

In this systematic literature review on the impacts on policymaking of SPIs we found that a majority of studies assessed global SPIs categorized as expert groups with studies at the non-global level being focused on the Global North. The main output of SPIs highlighted in the literature are assessments contributing, via social learning among policymakers, to more tangible impacts on policymaking, primarily in the form of policy formulation, enabled by several interdependent factors. For future research, we urge scholars to build on this conceptual framework to continue developing metrics for understanding and quantifying impacts on policymaking by SPIs, whether it is through the expansion of SPI categories or re-categorization according to SPIs depicting linear and co-production models of knowledge transmission. Another option could be emphasizing 'other' effectiveness factors and testing another framework for categorizing these, such as ACTA. A pivotal suggestion would be focusing on exogenous policy influences and the correlation with instances of social learning and policy changes, substantiating a causal link between outputs and impacts on policymaking.

Acknowledging the unique context SPIs need to be embedded in, we conclude this review with four practical recommendations resulting from our findings: Firstly, we encourage SPI stakeholders to go beyond assessments and consider designing SPIs in a way which offers a variety of outputs contributing to impacts on policymaking. This could range from short educational movies or podcasts to capacity building for policymakers and civil society (Gustafsson et al., 2020). Secondly, we urge SPI stakeholders to consider using the 15 effectiveness factors identified in this review to improve the effectiveness of SPIs depending

on their unique context. Thirdly, multi-level engagement between SPI stakeholders is necessary given the fact that environmental issues occur at multiple scales, thus, requiring collaborative production of diverse knowledge on environmental challenges. Fourthly, building upon the last point, we recommend SPI stakeholders to reflect on the benefits and downsides of their current institutional design and determining whether it is based on the linear model of science policy interaction and is able to effectively address complex environmental sustainability problems. Initiating a practical discussion on this could precipitate the transformation of several SPIs towards a co-production model (Turnhout *et al.*, 2019). Overall, by conceptualizing these interfaces as opportunities for the co-production of legitimate knowledge, we believe policymakers, scientists, and other key stakeholders of SPIs can embrace the plurality of worldviews and knowledges needed for solving the multiple environmental challenges the world is facing today.

CHAPTER 3: SPI LEGITIMACY

3. More than policy neutral: Justifying the Power of Science-Policy Interfaces through Legitimacy[21]

Chapter Summary

Science-policy interfaces are influential institutions that support policymakers in addressing complex environmental challenges. However, the power that SPIs wield in this capacity has been largely overlooked by the existing literature, which has primarily focused on the effectiveness of SPIs, often portraying them as apolitical and policy-neutral institutions.

Drawing on an integrative literature review, this article proposes a shift from effectiveness towards justifying the power of SPIs through assessing their legitimacy. We develop a framework for enhancing the democratic and epistemic quality of SPIs that comprises 12 criteria across the three dimensions of input, throughput, and output legitimacy. Input legitimacy criteria include inclusivity, consideration of multiple knowledge systems, and transdisciplinarity. Throughput legitimacy criteria address process accessibility, transparency, reflexivity, conflict management, and accountability. Output legitimacy criteria cover efficacy, accessibility, understandability, and dissemination.

The article provides a pathway for SPIs to foster both knowledge-based and participatory decision-making, by providing scholars and practitioners an evaluative tool to bridge the potential tensions between expertise and democratic representation in environmental governance.

3.1 Introduction

Policymaking requires knowledge especially in times of the world facing multiple crisis such as climate change, biodiversity loss, or pandemics (Maas et al., 2022). While the significance of knowledge in policymaking is not a matter of debate, the process of bridging science and policymaking remains a subject of extensive debate. This discourse primarily revolves around the role of 'science-policy interfaces' (SPIs) in facilitating the connection between knowledge and policy (Balvanera et al., 2020; Neßhöver et al., 2013; Young, Watt, van den Hove, et al., 2013).

Being key for addressing sustainability challenges, the objectives of SPIs are often linked to the idea of policy neutrality as seen with two of the most prominent SPIs. The Intergovernmental Platform on Climate Change (IPCC) states that its assessment reports are „policy-relevant and yet policy-neutral, never policy-prescriptive" (Havstad & Brown, 2017), while the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) mentions as one of its operational principles to „provide policy-relevant information, but not policy-prescriptive advice" (IPBES, 2012). The underlying logic is that SPIs provide a neutral knowledge base for policymakers who articulate and adjudicate related value disputes through political means in attempts to solve environmental problems (Sarewitz, 2004).

Following this logic of SPIs providing knowledge for policymakers to solve environmental problems, SPIs are often judged in terms of their ability to create impact (Heink et al., 2015; Mea et al., 2016; Young, Watt, van den Hove, et al., 2013). In the literature, this ability to create impacts is conceptualised as effectiveness (Hogl et al., 2012). SPI effectiveness is about SPIs contributing to political outcomes that would not have occurred in their absence, for instance, by shaping frames, discourses, and agendas, privileging policies, determining representation in deliberations, and fostering social learning (Haas, 2018). The extent to which SPI outputs can sway outcomes is the extent of their power. Power, in this sense, is not inherently negative but necessary for SPIs to create impact and contribute to sustainability transformations at various levels (Balvanera et al., 2020; Kates, 2011; Ojanen et al., 2021; Sarkki et al., 2020; N. Wagner et al., 2023).

However, the pursuit of effectiveness and impact raises important questions about the nature of SPI influence. While SPIs are often portrayed as neutral knowledge providers, their role in shaping sustainability transformations is inherently political and not value-neutral. For example, the IPCC's scenarios involving assumptions about carbon dioxide removal (CDR) technologies are not neutral regarding the use of such technologies (S. Beck & Oomen, 2021; Holz, 2018). This may overlook the crucial aspect of who benefits from SPI impacts, sometimes leading to exclusionary and marginalizing effects of SPIs (Beck et al., 2017; Hultman & Säwe, 2015; Turnhout et al., 2014). This striving for effectiveness often portrays SPIs as apolitical, neglecting the values, assumptions, and interests inherent in their processes (Fazey et al., 2018; Miller & Wyborn, 2020; Turnhout et al., 2020). By claiming to be policy-relevant but not prescriptive, SPIs often hide their power under the guise of claimed neutrality and the quest for effectiveness can often be considered „stealth issue advocacy" (Pielke, 2007).

The existing literature on SPIs has primarily focused on their effectiveness in influencing policy decisions and contributing to environmental governance. However, this emphasis on effectiveness overlooks the crucial question of the legitimacy of the power wielded by SPIs in shaping environmental policies and decision-making processes. This paper aims to address this gap drawing on the concept of legitimacy. Legitimacy is used to politically and epistemically justify the use of power (Bodansky, 1999; Peter, 2017). Politically, it is used to justify the power of political institutions such as government institutions as well as the European Union (EU) (Crum & Merlo, 2020; Schmidt, 2013), less formalised institutions such as multi-stakeholder initiatives (Mena & Palazzo, 2012) or more general themes of governance such as the climate-energy nexus (Zelli et al., 2020). Epistemically it is used to justify the quality of arguments (Habermas, 1976b;

Oxford Dictionary, 2022). Except for Haas (2017) who analysed the legitimacy of solutions-oriented global environmental assessments, neither the literature on legitimacy nor the literature on SPIs has analysed the justification of the power of SPIs through legitimacy so far.

Through an integrative literature review, we aim to combine insights from both bodies of literature and to answer the question of 'How can the power of SPIs be justified through legitimacy?'. To answer this main research question, the following subquestions are posed in the upcoming sections: How are SPIs conceptualised in the literature? (Section 3), How can the power and legitimacy of SPIs be conceptualised? (Section 4) and 'Which criteria can justify the legitimacy of SPIs?' (Section 5).

Answering these questions is critical as without a solid justification of the power of SPIs, SPIs risk being vulnerable to criticisms of democratic deficits and remaining marginal in their impact. SPIs might be dismissed as non-democratic means to influence policy through apolitical science (Bansard & Hel, 2022; Bogner, 2021; Boschele, 2020). Our work thus provides a pathway for SPIs that aspire not only to be policy-relevant but also to catalyse transformative shifts towards sustainability. Despite the broad consensus on sustainability as a normative goal, sustainability transformations are inherently political and value-laden. This paper, therefore, addresses the need for SPIs to embrace and justify their role in this complex, politicized landscape through legitimate procedures. Through these, we argue that SPI can foster effectiveness and contribute to legitimate impacts. With the conceptual framework developed in this paper, we provide SPI scholars and practitioners with an evaluative tool to enhance the democratic and epistemic quality of SPIs. This new focus on legitimacy could help scholars and practitioners rethink the institutional setups of SPIs.

3.2 Methods

This article is based on an integrative literature review (Snyder, 2019; Torraco, 2005). Integrative literature reviews aim to combine perspectives and insights from different fields or research traditions to result in the advancements of knowledge by generating new conceptual frameworks (Snyder, 2019, p. 335). Instead of systematically covering all articles ever published on a certain topic as systematic literature reviews, the aim of integrative literature reviews is a critical analysis of the literature and its main ideas and relationships of an issue (Torraco, 2005, p. 363). In this study, this method is useful for answering the research question of this study of how the power of SPIs can be justified through legitimacy[22].

For our study, we searched different scholarly research databases such as Google Scholar, Web of Science, Scopus, and JSTOR, searching for terms related to SPIs (e.g., boundary organizations, knowledge-policy interfaces, science-policy-society interfaces) and legitimacy and combinations thereof in the English language. We complemented this search with references from those papers. In contrast to a systematic literature review, no strict inclusion and exclusion criteria were used nor was the literature retrieved at one single point in time. Literature was chosen to capture both the most cited, established literature in the respective fields and the most innovative, relevant literature for answering the research question until

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[22] A similar approach is taken by Pickering et al. (2022) on a related topic.

reaching a point of saturation when no new relevant articles emerged for answering the research question (Randolph, 2007).

Literature Strand	Description	Disciplines	Range of Years	Most established literature based on citation	Most innovative for answering the RQ
Legitimacy Literature	This literature explores the concept of legitimacy, its theoretical foundations, and its application in various contexts.	Political science, sociology, philosophy, international relations, European studies	Literature from on mid-20th century with new literature in European Studies in the last two decades emerging.	Works by authors such as Beetham, (1991); Bodansky, (1999); Habermas, (1971, 1976); Lipset, (1969); Rawls, (2005); Scharpf, (1999); Schmidt, (2013)	Recent works exploring the application of legitimacy in new contexts, such as Crum & Merlo, (2020); Mena & Palazzo, (2012); Zelli et al. (2020).
SPI Literature	This literature examines the role, effectiveness, and challenges of science-policy interfaces in facilitating the connection between scientific knowledge and policymaking, particularly in the context of sustainability.	Sustainability science, environmental governance, science and technology studies, geography,	Primarily focused on literature from the last two decades, following the emergence of sustainability science in the late 1990s	Seminal works by authors such as (Cash et al., 2003; N. Clark, 2002; Kates et al., 2001; Neßhöver et al., 2013; Sarkki et al., 2014, 2015; van den Hove, 2007; Young, Watt, & van den Hove, 2013)	Recent works exploring critical perspectives on SPIs, such as Beck et al., (2017); Fazey et al., (2018); Goldman et al., (2018); Hultman & Säwe, (2015); Miller & Wyborn, (2020); Turnhout et al., (2020)
Overlap both literature strands	This literature explores the intersection of legitimacy and science-policy interfaces, addressing the justification of the power and influence of SPIs through legitimacy principles.	Combination of disciplines from the above strands	n.a.	Works by Haas (2017, 2018)	

Table 4: Overview of literature included in the integrative literature review

This resulted in SPI literature included in this integrative review published mainly in the last two decades and legitimacy literature being published since the mid-20th century, with the disciplinary scope of the study ranging from political science (political theory, political philosophy, public administration and international relations with a focus on European Studies) to disciplines such as sociology (knowledge sociology and science and technology studies), human geography, and sustainability sciences more generally (see table 1). The analysis of texts was carried out through what Torraco (2005) and Whetten (1989) refer to as 'conceptual reasoning'. Conceptual reasoning 'forms the basis for arguments and explanations' in integrative literature reviews (Torraco, 2005, p. 365). Through conceptual reasoning, we construct an argument that legitimacy provides a means to evaluate and enhance the justification of the power wielded by SPIs, and we derive a conceptual framework comprising of 12 criteria that can contribute to the legitimacy of SPIs. To showcase the usability of the framework, it has been applied to the IPCC and IPBES with specific examples for each criterion being searched in the literature.

3.3 Science-Policy Interface Literature

Science-Policy Interfaces in the Sustainability Science Literature

Within the broader field of sustainability science, the science-policy interface literature focuses on the connectivity between science and policy by understanding how 'today's relatively independent activities of research planning, monitoring, assessment, and decision support be better integrated into systems for adaptive management and societal learning' (Kates et al., 2001, p.649). Addressing this question of how science and policy can and should institutionally be better connected for enhancing sustainability transformations, literature on SPIs emerged in the last two decades (Jabbour & Flachsland, 2017; N. Wagner et al., 2023).

The most prevalent understanding of SPIs is that they are a process bringing together scientists and other actors in the policymaking process (Borie et al., 2021; Soomai, 2017b). The commonly cited definition of SPIs by Sybille van den Hove (2007), characterizes SPIs as „social processes that involve interactions between scientists and other actors in the policy process, and which enable the exchange, co-evolution, and joint construction of knowledge with the goal of improving decision-making" (van den Hove, 2007). Narrowing this broad understanding of SPIs down, other literature understands SPIs as organisations 'purposively set up to support the interaction processes facilitating connectivity between science and other governance contexts' (Sarkki et al., 2020, p. 21). Through connecting organisations from knowledge, policy, civil society and business, SPI organisations are often at the centre of what can be called a SPI network (UNEP, 2017). SPI networks can encompass different kinds of 'organised exchanges' with different degrees of institutionalisation, ranging from informal networks bringing together individuals to institutionalised platforms connecting different organisations (Dunn & Laing, 2017; Görg et al., 2016; Kelemen et al., 2021).
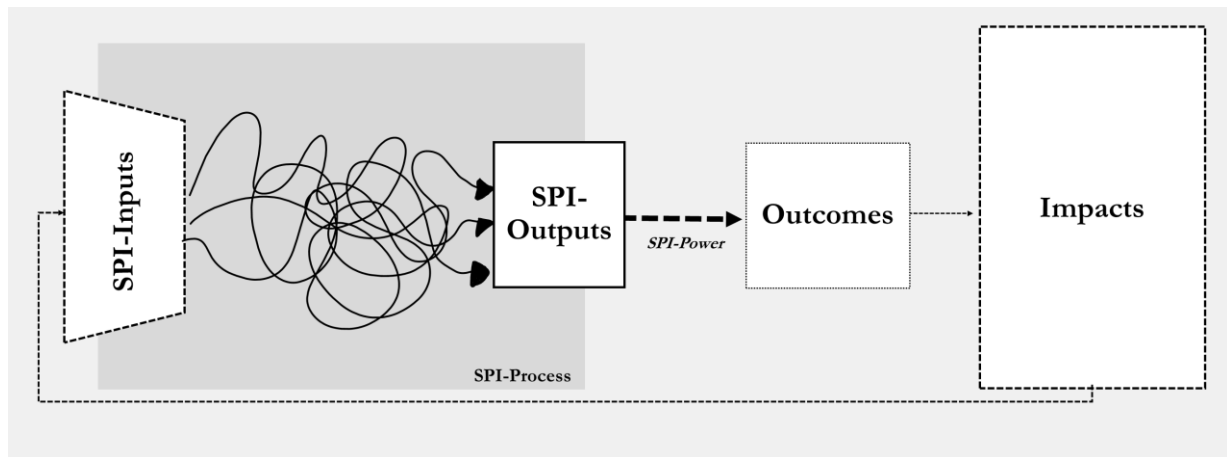
Figure 8: Conceptual framework of SPIs

Illustrated in Figure 8, SPIs are conceptualised as fuzzy co-production processes designed to bring together knowledge and policy. Through the SPI knowledge co-production process, SPI inputs are transformed into SPI outputs (Easton, 1968; van den Hove, 2007). SPI inputs can be categorised into political and epistemic inputs. Political inputs describe the interest demands of stakeholders, while epistemic inputs are comprised of different forms of knowledge. While epistemic inputs tend to be knowledge-oriented, political inputs are characterised by interests. An overlap between the epistemic and the political input within SPI becomes possible through normative co-production (Wyborn et al., 2019). SPI outputs are the tangible products of SPI such as policy briefs, reports, assessments, workshops, dialogues and presentations which synthesize the evidence on a topic relevant to policy (N. Wagner et al., 2023).

Effectiveness Focus and its Problem of Hiding Power

Much of the sustainability science literature on SPIs focuses on how the effectiveness of SPIs can be improved (Sarkki et al., 2014, 2015; N. Wagner et al., 2023). Effectiveness in this literature is often understood as the ability of SPIs to create impacts (Hogl et al., 2012). Following a theory of change, SPIs contribute to these impacts through their outputs (Belcher et al., 2017; Frey, 2018; Ramirez & Belcher, 2020).

While the relationship between SPI outputs and outcomes is complex and co-evolutionary (Jasanoff, 2004), SPI outputs interact with broader sets of motivators, discourses, and governance processes across levels, shaping outcomes in a „fuzzy" manner (N. Klenk, 2018). SPI outputs can directly inform policymakers' decision-making when perceived as credible, relevant, and legitimate by different policy communities and societal actors (Cash et al., 2003). Moreover, the co-production processes arranged by SPIs, involving scientific and policy actors (J. M. Chambers et al., 2021), foster ownership over the outputs, increasing their uptake in decision-making. Crucially, SPI outputs are often produced on policy actors' demand, addressing policy-relevant questions, and enhancing their relevance and likelihood of use (Sarkki et al., 2020). The extent to which SPI outputs contribute to outcomes is the extent of their effectiveness and can be named 'SPI-power'.

Outcomes are the changes which might be, partially at least, motivated by the outputs of SPIs (Hogl et al., 2012; Pregernig and Böcher, 2012; Young et al., 2013). Outcomes can occur within politics, civil society, media and business for example, and include changes in strategies or agendas (UNEP, 2017; N. Wagner et al., 2023). These outcomes are expected to contribute to impacts, namely the biophysical changes to which the outcomes of SPIs are expected to contribute (Hogl et al., 2012, p. 14; Ojanen et al., 2021).

The ability of SPIs to create impact hinges on particular effectiveness factors (N. Wagner et al., 2023, p. 59). In an often-cited article, Cash et al. (2003) have categorised these factors as into credibility, relevance and legitimacy, often abbreviated as 'CRELE'. Credibility is understood as the scientific adequacy measured by multiple criteria including reliability, validity, and adequacy. Relevance, or salience, refers to the usefulness of information for policymakers and societal needs, which is encapsulated by these factors such as timeliness, simplicity, and meeting the demand for knowledge (Sarkki et al., 2014). Finally, the understanding of legitimacy in this literature relates to „issues of ethics and fairness in knowledge generation and knowledge exchange" (Ojanen *et al.*, 2021, p.11), which includes factors of consensus, wide participation, and a range of views (Sarkki et al., 2014). Effectiveness factors have been complemented through iterativity or the availability of resources (Sarkki et al., 2015; N. Wagner et al., 2023).

While much of the SPI literature focuses on SPI-effectiveness, some criticise this effectiveness focus in a more general sense (Hoppe, 2005; Hoppe et al., 2013; Lahsen & Turnhout, 2021; Turnhout et al., 2016). Striving for effectiveness often pictures SPIs as apolitical organisations ignoring how SPI organizations and processes embed certain values, assumptions and interests (Goldman et al., 2018; Lövbrand, 2011). Ignoring these factors shaping the outputs of SPIs can have exclusionary, marginalising impacts (Fazey et al., 2018; Miller & Wyborn, 2020; Turnhout et al., 2020). Such adverse consequences of SPIs have been observed and documented in various cases (Beck et al., 2017; Hultman & Säwe, 2015; Turnhout et al., 2014). Instead of upholding the apolitical picture of SPIs by focusing on the effectiveness of SPIs, we argue in the following section that SPIs should be considered as powerful institutions that influence political outcomes and thus require legitimacy.

3.4 Power and Legitimacy of SPIs

The rather exclusive focus on effectiveness of the SPI literature might overlook questions of for whom SPIs create impact because the underlying power of SPIs is not systematically reflected and justified (Brugnach et al., 2017; Goldman et al., 2018; Miller & Wyborn, 2020; Munoz-Erickson, 2014; Nowotny et al., 2013; Wyborn et al., 2019). Missing the 'inevitable politics of configuring knowledges' (Miller & Wyborn, 2020, p.90), it is argued that the sustainability science literature fails to consider SPIs being embedded in power structures and being themselves powerful institutions (Goldman et al., 2018; Wyborn et al., 2019). In this section, we first show that SPIs are powerful institutions to secondly argue that the power of SPIs needs to be justified. For this justification of the power of SPIs, we draw on the legitimacy literature.

Power and SPIs

SPIs are considered to be powerful, both politically and epistemically: Through their outputs, SPIs contribute to outcomes which would not have occurred in their absence (Haas, 2018). According to this understanding, SPI power is the capacity, potential, ability, or wherewithal of SPIs to create outcomes through their outputs (Pitkin, 1985). The more the SPI output shapes outcomes in politics, civil society, media or businesses, the more power the SPI has. In different terms, if the outcomes are determined solely by external factors the SPI has no influence on, then the SPI is powerless. This means that the extent to which SPI outputs contribute to outcomes is the extent of their power (*illustrated with a dashed arrow in Figure 8*). Concretely, (Haas, 2018) describes that SPIs exercise power through 'shaping frames and discourses, setting agendas, privileging policies, shaping the determination of who is entitled to representation in deliberations about technical and environmental issues, privileging reasoned discourse over emotional or purely interested discourses, and contributing to social learning' (Haas, 2018, p.4). Therefore, the power of an SPI is conceptualised as the degree to which its outputs can sway outcomes beyond factors exogenous to the SPI.

This emphasis on the influence of SPIs draws attention to the societal structures SPIs are embedded. According to Turnhout et al. (2016), SPIs operate within concrete contexts that shape their actions, while at the same time, SPIs shape their environments. This can be seen, for instance, in IPBES' Global Assessment on Biodiversity and Ecosystem Services (IPBES, 2019). Packaging the conservation of nature as a service is no neutral act of translation but makes nature conservation a tradeable commodity instead of valuing biodiversity for its intrinsic value (Borie & Hulme, 2015; Kadykalo et al., 2019). This creation of global knowledge on biodiversity through a 'truth regime' like IPBES, Turnhout et al. (2016) argue, shows how knowledge and power are tightly intertwined, serving a particular expression of power: 'How one knows constrains how one governs and how one governs shapes what one needs to know' (ibid., p.69).

While we acknowledge the importance of situating SPIs like IPBES into the broader power structures and appreciate the Foucauldian understanding of power and knowledge together, our understanding of SPI power is focused on power as „capacity or potential" (Arts & Tatenhove, 2004): Through their outputs, SPIs have the potential to contribute to outcomes. With this, power is not seen as domination or against someone's will (Weber, 1964); instead of being problematic the political and epistemic power of SPIs is desired. A powerless SPI is useless; SPIs exist to create impact and these impacts are needed. Thus, we define SPI power as 'their political and epistemic capacity to achieve impacts'. The question, however, is who benefits from these impacts and whether that can be justified. In other words, we should ask not whether SPIs should be powerful and impactful, but under what conditions their power and impacts are justified.

Legitimacy of SPIs

To justify the power of SPIs we draw upon the concept of legitimacy. In the literature, legitimacy is understood as the justification of power (Beetham, 1991a; Bodansky, 1999). Legitimacy has been widely

used for the analysis of powerful (state) institutions concerning the quality of their democratic processes (S. Bernstein, 2011; Lipset, 1969; Peter, 2017; Rawls, 2005; Weber, 1964). In its normative understanding, legitimacy is used to improve or evaluate the processes of political institutions in democracies (Pettit, 2012). However, the underlying assumption is that through legitimate processes the impact is likely to be acceptable (Christiano, 2004; Habermas, 1971; Pettit, 2012; Rawls, 2005).

Given this focus on the quality of processes, our analysis of SPI legitimacy rather concerns how the impacts of SPIs are created rather than the quality or substance of the impacts themselves. With this process-focus, legitimacy has been conceptualised as 'input, throughput and output legitimacy' of political institutions in democracies (Haas, 2017; Scharpf, 1999; Schmidt, 2013; Mena & Palazzo, 2012). Inspired by Easton's systems theory, Scharpf (1970, 1999) developed the concepts of input and output legitimacy to analyse the legitimacy of the EU's institutions. Input legitimacy results from the responsiveness to citizens' concerns as a consequence of participation *by* the people, output legitimacy is about the effectiveness of political institutions *for* the people (Schmidt, 2013, p. 2). Next to input and output legitimacy, Beck and Zürn (1998) and Schmidt (2013) added 'throughput legitimacy' to describe the quality of the decision-making process, describing what goes on in the 'black box' of decision-making within democratic governance (Steffek, 2019). Applied to SPIs, SPI throughput-legitimacy relates to all procedural aspects of how SPI inputs are transformed into outputs. While throughput-legitimacy has been among the 'most successful conceptual innovations' in recent political science literature (Steffek, 2019), a conceptual overlap especially between input and throughput legitimacy has been noted (Mosley & Wong, 2021; Stephenson, 2023).

Next to justifying the power of SPIs in political terms, legitimacy is found to be useful for justifying the power as well in epistemic terms: Legitimacy is not only about the quality and acceptability of power of political institutions in democratic terms but also about 'the quality of being based on a fair or acceptable reason' (Habermas, 1976b; Oxford Dictionary, 2022). Legitimacy hence relates not only to political arguments for institutions being justified in exercising political power but can also be extended to the analysis of the quality of knowledge (Anderson, 2008; Cerovac, 2020; Hausknost, 2012).

With this, legitimacy provides a means of bridging the potential tensions between technocracy and democracy in SPIs (Bader, 2014). With technocracy being described as the rule of the experts and democracy as the rule of the people, there seems to be a possible trade-off between expertise on the one hand and wide, democratic participation on the other (H. Collins & Evans, 2006). With elected politicians relying on unelected experts, it is argued that they might take away the elected political authority from the sovereign people (Boschele, 2020, p. 479). Legitimacy of SPIs might help to bridge the potential conflicts between democracy and expertise by bringing together arguments for justifying the democratic and epistemic power of SPIs. With this, legitimate SPIs can help make knowledge and democracy complementary.

3.5 SPI Input, Throughput and Output Legitimacy

Defined as the justification of the political and epistemic power of SPIs, the concept of SPI legitimacy as presented above does not yet offer concrete guidance on how to improve the democratic and epistemic

quality of SPIs. Given that the 'how' to create legitimate impacts is core to the procedural understanding of legitimacy, this section aims to provide practical strategies for enhancing SPI legitimacy. Through the integrative literature review, we identify key criteria that can be used to evaluate and enhance the legitimacy of SPIs throughout their entire process - from the initial inputs, through their operational procedures, to the final outputs and their dissemination. In subsections 5.1 - 5.3, input, throughput and output legitimacy criteria are presented, illustrated in Figure 9 and Tables 5 to 7. Later the section presents an exemplary application of the framework for the IPCC and IPBES (Tables 5 to 7, column 3).
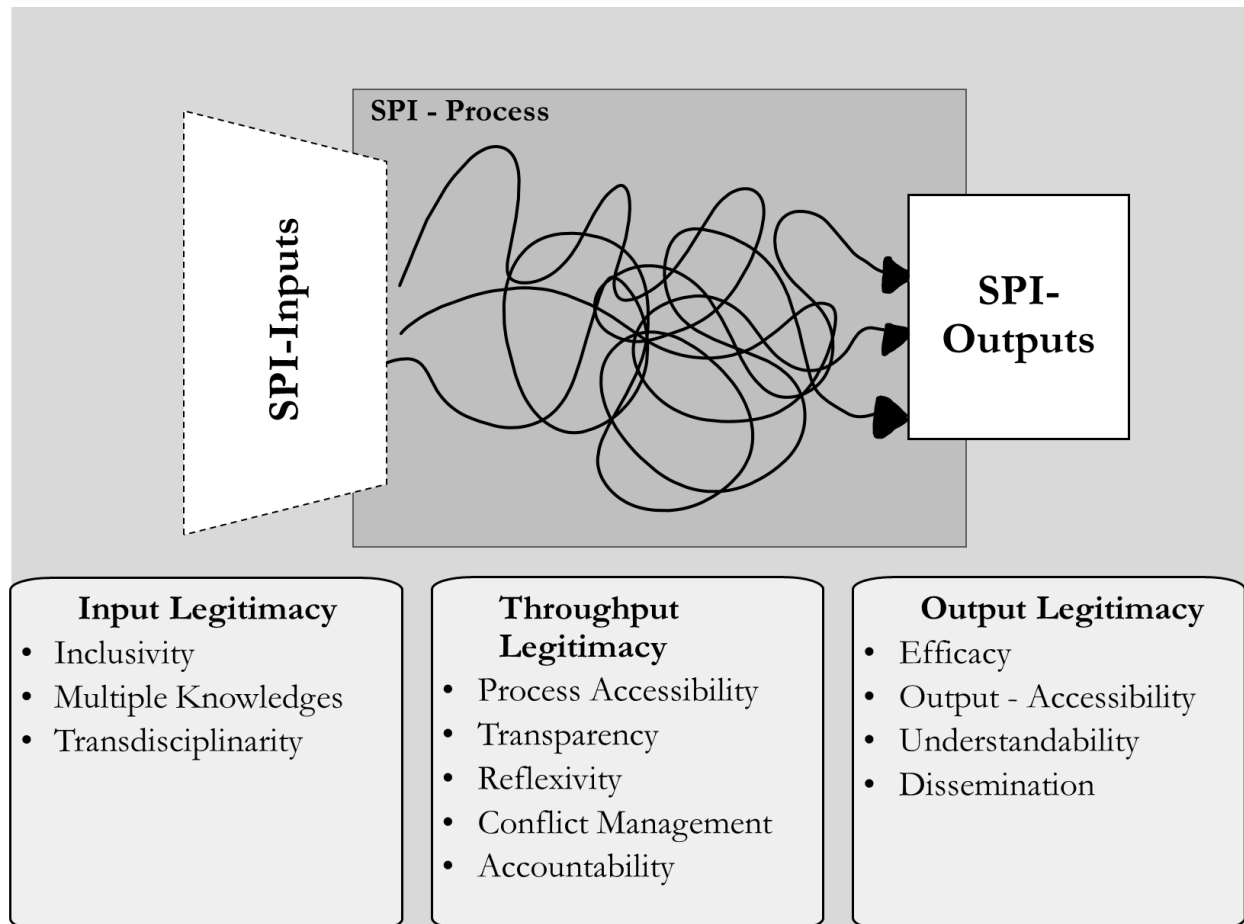
Figure 9: Legitimacy criteria of SPIs alongside the SPI process

SPI Input Legitimacy

Input legitimacy, a concept rooted in participatory democracy, emphasizes the inclusion of all relevant stakeholders in institutional decision-making processes (Schmidt, 2013; van Tatenhove, 2011, p. 101). Through our integrative literature review, we have identified three key criteria of input legitimacy pertinent to SPIs (see Table 5).

Input Legitimacy Criterion	Exemplary Operationalisation Questions	Examples illustrating the institutionalisation of criteria by IPCC and IPBES	Exemplary References
Inclusivity	- Are affected stakeholders represented directly or indirectly in the SPI process? - Is it ensured that there is no discrimination concerning gender, social class or race?	Intention of IPCC to increase gender and regional variety after criticisms (Biermann, 2001).	(Borie & Hulme, 2015; Haas, 2017; Koetz, 2011; Schmidt, 2013)
Multiple knowledges and perspectives	- To what extent is knowledge other than scientific knowledge included in the SPI process?	Intention of IPBES to include Indigenous and Local Knowledge in all parts of the assessment, for instance, through the Open-ended IPBES stakeholder network ONet or the International Indigenous Forum on Biodiversity and Ecosystem Services (IIFBES) (IPBES, 2023; Krug et al., 2020; Obermeister, 2017, p. 83)	(S. Beck, 2011; Savaresi & Chiarolla, 2015; Soomai, 2017a)
Transdisciplinary	- To what extent are experts' scientific disciplines social and natural science involved in the SPI process? - To what extent is the knowledge included in the SPI process co-produced between experts from different disciplines?	Intention of IPBES to increasingly include social science in the process (Gustafsson et al., 2020; Koetz et al., 2012) and intention of the IPCC to include transnational city networks in its upcoming cities report (IPCC, 2023)	(S. Beck, 2011; J. Schindler et al., 2016; Sitas et al., 2019; Tynkkynen, 2015) (Mauser et al., 2013; van der Hel, 2016)

Table 5: Criteria of input legitimacy

The first criterion, inclusivity, is fundamental to democratic processes across various institutional contexts. It refers to the equal inclusion of those affected by a decision in the decision-making process (Böhmelt et al., 2016). Inclusivity ensures diversity in terms of gender, race, and social class, thereby preventing discrimination (Díaz-Reviriego et al., 2019). This principle is considered crucial across multiple domains, including EU governance, multi-stakeholder initiatives, and global science regimes (Haas, 2018; Mena & Palazzo, 2012; Scharpf, 1999; Schmidt, 2013). In the context of SPIs, inclusivity serves both epistemic and democratic purposes. Epistemically, inclusive practices enhance the quality of knowledge drawing upon a broader range of expertise, experiences, and perspectives, leading to a more comprehensive understanding of complex environmental issues (Sarkki et al., 2014; Turnhout et al., 2020; Young et al., 2013). Democratically, inclusivity in SPIs ensures that those affected by SPI outputs have a voice in their development (Smith & Wales, 2000). By including a diverse range of stakeholders, SPIs can ensure that their outputs reflect a broader societal perspective and address the concerns of various affected groups (Koetz et al., 2012). The SPI effectiveness literature emphasizes that such inclusive practices contribute to the

perceived fairness and credibility of SPIs, which in turn enhances their effectiveness (Sarkki et al., 2015; Young et al., 2013).

Another criterion effecting the input legitimacy of SPI is the degree to which SPIs consider multiple sources of knowledge including local and Indigenous knowledge (Hulme, 2009; Ramirez & Belcher, 2020; S. Schindler et al., 2016). This criterion is epistemically important for SPI legitimacy as knowledge is not reducible to scientific knowledge only. To ensure a holistic understanding of the issues at hand it is argued that for the epistemic legitimacy of SPIs, the consideration of knowledge other than science is needed (S. Beck, 2011; Savaresi & Chiarolla, 2015; Soomai, 2017b).

Very closely related to this is the criterion of transdisciplinarity. Transdisciplinarity refers to the collaboration between different scientific disciplines together with non-academic stakeholders (Mauser et al., 2013; van der Hel, 2016). Scientific knowledge relies on stakeholder engagement and is needed for sustainability solutions (J. Bernstein, 2015). It is considered important for ensuring the epistemic legitimacy of the SPI as it contributes to a more holistic understanding of the problem at hand (Takeuchi et al., 2021). Further transdisciplinarity enhances the policy-relevance of SPIs (Guido et al., 2016)[23].

SPI Throughput Legitimacy

Throughput legitimacy, a concept central to institutional processes, focuses on the procedural quality of SPIs (Schmidt & Wood, 2019; Steffek, 2019). Our integrative literature review has identified five key criteria of throughput legitimacy pertinent to SPIs (Table 6).

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[23] It is worth noting that transdisciplinary research projects can themselves function as SPIs ((Timaeus et al., 2011). As such, these projects should also strive to meet the legitimacy criteria developed in this conceptual framework, further emphasizing the broad applicability of these principles in bridging science and policy for sustainability.

Throughput Legitimacy Criterion	Exemplary Operationalisation Questions	Examples illustrating the institutionalisation of criteria by IPCC and IPBES	Exemplary References
Process-Accessibility	- To what extent are physical, language, and practical barriers mitigated for stakeholders to substantively participate in the SPI process?	Intention of IPBES to reduce barriers to authors from Global South by covering their travel costs and paying a daily allowance (IPBES, 2021)	(Heinisch, 2021; Schmidt & Wood, 2019) (Díaz-Reviriego et al., 2019; Schmidt & Wood, 2019)
Transparency	- Is the information on the process of how stakeholders are selected for providing input to the SPI publicly available and comprehensible? - Is the information on how SPI outputs are formed publicly available?	Transparency of IPCC by publishing all review comments and how they were handled by authors (Livingston & Rummukainen, 2023)	(Hetemaki, 2019; Schmidt & Wood, 2019; Skea et al., 2021)
Reflexivity	- Are reflexive activities occurring intending to mitigate possible power asymmetries between stakeholders?	Intention to mitigate power asymmetries between IPCC chair and scientists, governments and civil society through the 'Talanoa format[24]' (IPCC, 2018b; Kirsch, 2021)	(Borie et al., 2020; Lahsen & Turnhout, 2021).
Conflict Management	- To what extent are there mechanisms which prevent bribes, misuse or manipulation of evidence or information? - Is there a policy preventing conflicts of interests?	Intention of IPBES to prevent conflicts of interests through a respective policy (Larigauderie, 2015)	(Tremblay et al., 2016)
Accountability	- Are there mechanisms that hold SPI actors accountable for achieving or failing to achieve their accounted miss-ions?	Establishment of mechanisms by IPCC following the so-called climate gate affair, such as intensified peer review processes (S. Beck, 2012; Hogl et al., 2012)	(Schmidt & Wood, 2019)

Table 6: Criteria of throughput legitimacy

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[24] The Talanoa format was established by the presidency of Fiji in the UNFCCC COP 23 to promote cooperation and the exchange of ideas by intentionally mitigating differences in hierarchy and rank of different parties and stakeholders (Kirsch, 2021).

The first criterion is process-accessibility referring to the procedures ensuring that SPI-stakeholders and all the diverse stakeholders participating in the SPI process are not only formally included but have equitable access and are substantially included (Díaz-Reviriego et al., 2019; Schmidt & Wood, 2019) [25].

It includes, for instance, the physical accessibility of the location by ensuring accessibility for people with disabilities in the locations where the SPI interactions are taking place (Raisio et al., 2014). For SPI processes involving multi-lingual stakeholders, language accessibility is crucial; this can be addressed by providing translation services to enable substantial participation by all stakeholder (A. Taylor et al., 2015; Verhasselt, 2024). All of the examples enhance democratic and epistemic legitimacy: Democratically, the power of the SPI is more justified if substantial access and participation are ensured which also enhances the knowledge quality (Cohen-Blankshtain & Sulitzeanu-Kenan, 2021).

Transparency in the political system refers to citizens and other interested stakeholders having access to information on how political decisions come about (Héritier, 2003; Schmidt & Wood, 2019, p. 732). As a criterion of SPI throughput legitimacy, transparency means the public has access to information that allows them to comprehend how SPI outputs are formed. Two forms of SPI transparency can be distinguished. Firstly, SPI transparency involves openness about the selection of SPI participants and their inputs. This includes providing information about the procedures used to select participants for the SPI process. Secondly, it refers to making public the processes that SPIs follow to generate knowledge and transform it into outputs. Transparency is regarded both as important for enhancing the democratic legitimacy of political institutions (Schmidt, 2013) as well as enhancing the knowledge quality of SPIs (Hetemaki, 2019; Skea et al., 2021).

To be considered throughput legitimate, an SPI process must further institutionalize reflexivity about potential power asymmetries among stakeholders (Borie et al., 2020; Lahsen & Turnhout, 2021). Fostered as a key practice in research by feminist scholars, the power-critical practice of reflexivity 'involves disclosing the normative assumptions, values and concepts underlying the research processes, problematizing differences in the status and effectiveness of different forms of knowledge at various research stages, as well as power differentials between non-academic actors and scientists and helps to examine their positionality (Staffa et al., 2022, p. 48). In the context of SPIs, this translates to a conscious examination by participants of the power dynamics at play within the interface. Ideally, this awareness leads to efforts to mitigate these imbalances. The importance of this practice is underscored by Turnhout et al. (2020), who caution that without acknowledging these power dynamics, participatory processes may inadvertently reinforce the very problems they aim to solve, while simultaneously being legitimized by the appearance of inclusivity (Turnhout et al., 2020).

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[25] Termed process accessibility in contrast to output accessibility described in section 5.3 below.

Further, we identify conflict management procedures as key for throughput legitimacy: Following Tremblay et al. (2016) an ethical infrastructure of conflict management can prevent bribe misuse or manipulation of evidence or information including a clear conflict of interest policy.

Lastly, accountability refers to the provision of information by an actor or organization, discussion or deliberation on that information, and the (potential) imposition of rewards or sanctions in cases of misconduct (Schmidt & Wood, 2019). In the context of SPIs, the criterion of accountability can be thought of as the possibility of SPI actors being held accountable for achieving or failing to achieve their mandated missions.

SPI Output Legitimacy

Output legitimacy refers to the respective institutions' ability to solve collective problems (Scharpf, 1999; Steffek, 2015). It is about the ability of institutions to create legitimate impacts for the respective target audience. SPI output legitimacy is hence associated with the effectiveness of the institution in question in creating impacts. Four criteria are identified through the integrative literature review (Table 7).

Output Legitimacy Criterion	*Exemplary Operationalisation Questions*	*Examples illustrating the institutionalisation of criteria by IPCC and IPBES*	*Exemplary References*
Efficacy	- To what extent are the outputs tailored to the problem at hand?	Intention of IPCC outputs being useful for policy makers 'at all levels' to address climate change (IPCC, 2021).	
Output-Accessibility	- To what extent is the SPI output publicly accessible?	IPCC and IPBES reports are both publicly available on their respective websites.	(A. Taylor et al., 2015)
Under-standability	- To what extent is the SPI output comprehensible for the relevant stakeholders?	Intention to make the IPCC reports understandable and comprehensible, for instance, through the summary for policymakers.	(Heink et al., 2015; Howarth & Painter, 2016)
Dis-semination	- Are there various formats of SPI outputs? - To what extent is the SPI output distributed through media engagement?	Intention of IPBES and IPCC to disseminate the outputs through traditional media engagement and social media work.	(Gomez-Diaz & Recio, 2021; Mea et al., 2016; Tripathy et al., 2017)

Table 7: Criteria of output legitimacy

The first SPI output legitimacy criterion, efficacy, is about 'the extent to which the output fits the problem at hand, and is relevant for solving it effectively' (Mena & Palazzo, 2012, p. 541). With regards to SPIs, this refers to the SPI output being relevant for the stakeholders intending to use it. For instance, the IPCC aims to make its outputs relevant to policymakers responsible for tackling climate change.

We further identify output-accessibility as SPI output legitimacy criterion. In contrast to process-accessibility, output-accessibility refers to easy access to SPI outputs, for instance, by making them available online (A. Taylor et al., 2015). Additionally, we find the understandability of SPI outputs to be an important criterion for SPI output legitimacy. To be output-legitimate, SPI outputs need to be accessible and

understandable for their key audiences (Heink et al., 2015; Howarth & Painter, 2016). Additionally, we identify the criterion of dissemination to be relevant for output legitimacy. It refers to the adequate dissemination of the SPI output to its key audience (Gomez-Diaz & Recio, 2021; Mea et al., 2016; Tripathy et al., 2017). This could imply as well that SPIs do not only produce an assessment report as their output but create other formats such as videos, podcasts, or theatre (Hetemaki, 2019; N. Wagner et al., 2023).

Application of the Legitimacy Framework

In this section we intend to demonstrate the useability of the conceptual framework developed through the integrative literature review. Because the goal of this paper was to develop a conceptual framework on the legitimacy of SPIs, this application is of demonstrative intent; a thorough SPI legitimacy evaluation would require a detailed analysis based on empirical data and is beyond the scope of this paper. We demonstrate the framework's usability concerning two of the most prominent SPIs, the IPCC and IPBES. These SPI organisations have been selected because they have been studied extensively in the literature (N. Wagner et al., 2023) and might be familiar to the reader. In addition to this section, examples illustrating the institutionalisation of each criterion within IPCC and IPBES are provided in collumn three of tables 4 to 6 above.

Being the world's most prominent SPI, the IPCC faced criticism regarding all aspects of input legitimacy in the past. There was critique concerning the limited participation of female scholars and scholars from the Global South and, the limited inclusion of Indigenous and local knowledge as well as social sciences (S. Beck, 2011; Biermann, 2001; Borie et al., 2021). In response to this critique, the IPCC showed intentions to increase gender and regional diversity as well as the inclusion of social science and Indigenous knowledge in their processes over the last assessment periods and thereby increased its SPI input legitimacy (S. Beck et al., 2014; Gay-Antaki & Liverman, 2018; Standring & Lidskog, 2021). With regards to SPI throughput legitimacy, after criticisms, the IPCC increased its transparency through the publication of review comments and how they were addressed (Livingston & Rummukainen, 2023). Further, the IPCC provided more background on its integrated assessment models (Skea et al., 2021). Finally, for the output legitimacy criterion of efficacy, the IPCC aims to produce outputs that are tailored to the needs of policymakers at all levels (IPCC, 2021). For the upcoming special report on cities, the IPCC hence includes city practitioners next to the authors and government delegates to ensure practical utility (IPCC, 2023).

Being institutionalized more than a decade later than the IPCC, IPBES learnt from some of the legitimacy criticisms of the IPCC and intended to mitigate these within its institutional set-up (S. Beck et al., 2014; Borie et al., 2021). For instance, from its inception, IPBES intends to include Indigenous and local knowledge in its assessments, a.o. through the International Indigenous Forum on Biodiversity and Ecosystem Services (IIFBES) (IPBES, 2023; Obermeister, 2017; Tengö et al., 2017). However, given the physical, language, and financial barriers for Indigenous people's representatives and stakeholders to IPBES meetings and workshops, the inclusion of Indigenous knowledge is still beset with difficulties (Oubenal et al., 2017; Savaresi & Chiarolla, 2015). To address these difficulties, IPBES showed intentions to reduce barriers, for instance, through (partially) providing translation services and covering travel costs for

participants from the Global South or the IPBES Fellows programme (Hrabanski et al., 2017; IPBES, 2017, 2021). This example of IPBES intention to include multiple knowledge systems while having access difficulties point to the importance of considering all dimensions of legitimacy – only with throughput legitimacy input legitimacy can be valued.

Overall, these two examples intend to demonstrate the usefulness of our conceptual framework for the development of new insights into the legitimacy of SPIs in concrete empirical cases. On the one hand, our framework can be used to scholarly analyze how SPI organizations adapt their institutional designs over time to meet general legitimacy expectations. On the other hand, our framework provides practitioners with a detailed set of criteria to improve the power of SPIs and their justification. Taken together, these two features of our conceptual framework allow for a comprehensive analysis of the legitimacy of SPIs within contexts of global sustainability governance.

3.6 Discussion

Bringing together Knowledge and Democracy

Based on the integrative literature review carried out in this paper, we argue that legitimate SPIs have the potential to bring together knowledge and democratic participation. The legitimacy literature finds the potential for conflict between expertise needed for effective policymaking on the one hand (output legitimacy) and participatory democratic decision-making on the other (input legitimacy) in political systems (Kruuse et al., 2019; Papadopoulos & Warin, 2007; Schmidt, 2013), we find that SPIs hold the potential to transform the relationship between input and output legitimacy from antagonistic to synergistic: By fostering seamless integration of knowledge and democratic participation, SPIs bringing together knowledge and policy following the criteria of input legitimacy are expected to contribute to outputs which can foster sustainability outcomes and impacts.

Co-Production and SPI-Legitimacy

Knowledge co-production and SPI-legitimacy are conceptually closely related to each other. The 'co-production' (Miller & Wyborn, 2020), 'collaborative' (Koetz et al., 2012) or 'stakeholder' (Pielke, 2007) model of science policy interaction is about iteratively uniting ways of knowing and acting through bringing together knowledge holders and policymakers and other stakeholders for collaborating as well as „reasoning together" (Jasanoff, 1998; Koetz et al., 2012; Wyborn et al., 2019). Characterized by diverse participation and different types of knowledge, knowledge co-production can be contrasted with the linear model of science policy interaction according to which the exchange between science and politics is one-directional and science „speaks truth to power" (Bremer & Meisch, 2017; Price, 1981; Weingart, 1999). Bringing together scientists, policymakers, affected stakeholders and active citizens with their diverse knowledge, gathered in different places, at different scales, and using different „starting points, assumptions, and rules" (Berkes, 2009, p. 1694), co-production has some significant overlap with the criteria of SPI input legitimacy.

As it often remains unclear who benefits from the improvement of sustainability designed in co-productive processes, co-production is critiqued on similar accounts as critiques of apolitical SPIs to fail to adequately embrace questions of power (J. M. Chambers et al., 2021; Goldman et al., 2018; N. L. Klenk et al., 2015; Wyborn et al., 2019).

The Importance of Throughput Legitimacy for Justifying Power

Behind a 'veil of apoliticalness' (often supported by the conceptual fuzziness of sustainability) we have shown that SPIs fail to address highly relevant, normative and political questions related to SPI-power which can be addressed through a legitimate SPI processes. Through a legitimate process, we argue that questions such as 'What should count as a collective problem and who benefits from the solution? For whom should the impacts be created? Who should benefit and who should not benefit from the impacts the SPI is contributing to?' can be answered.

Key to addressing these political questions in legitimate SPIs is throughput legitimacy. With adherence to accessibility, transparency, reflexibility, conflict-management procedures and accountability, throughput legitimacy is at the heart of legitimate SPI processes. Given the procedural nature of legitimacy, the risk of only formally adhering to the criteria of input legitimacy without ensuring the substantive inclusion of stakeholders or different knowledge and disciplines can be prevented through throughput legitimacy.

Investments into a Legitimate Process

It should be noted that enhancing the quality of this process, however, is resource- and time-intensive. Given that legitimacy is more encompassing than effectiveness, it is important to acknowledge the higher costs possibly associated with enhancing SPI legitimacy (Hogl et al., 2012). Ensuring the inclusion of affected stakeholders, multiple knowledge, accessibility, accountability, etc. comes at a cost. If through this legitimacy the impact of the SPI process is then improved, we believe that this money is well-invested.

3.7 Conclusion

The existing literature on SPIs has predominantly focused on their effectiveness in influencing policy decisions, often portraying them as objective and policy-neutral entities. However, this emphasis on effectiveness overlooks the critical question of justifying the power wielded by SPIs in shaping environmental governance processes. Under the guise of policy neutrality, SPIs may inadvertently promote certain interests or agendas over others (Pielke, 2007).

To address this concern, this paper proposes a conceptual shift from effectiveness towards assessing the legitimacy of SPIs as a means of justifying their power. Drawing from an integrative literature review, we have conceptualized the power of SPIs and argued that this power necessitates a justification through legitimacy. The paper identifies 12 criteria across three dimensions – input, throughput, and output legitimacy – that can enhance the democratic and epistemic quality of SPI processes.

By embracing and justifying their role in the complex landscape of sustainability transformations through legitimate procedures, SPIs can foster both knowledge-based and participatory decision-making. This framework provides a pathway for SPIs to increase their policy relevance while navigating the inherent tensions and power dynamics that arise when bridging science and policymaking.

The conceptual framework developed in this paper offers scholars and practitioners an evaluative tool to enhance the legitimacy of SPIs. By continuously assessing and improving their legitimacy through the proposed criteria, SPIs can strengthen their justification for wielding power in environmental governance processes. Ultimately, this paper contributes to the ongoing discourse on the role and impact of SPIs in sustainability transformations. By addressing the power of SPIs through legitimacy, SPIs can navigate the complexities of environmental decision-making towards more inclusive and equitable sustainability governance.

CHAPTER 4: LEGITIMATE CLIMATE ACTION PLANS

4. How Legitimate Are Urban Climate Planning Processes? A Comparative Assessment of Accra, Ahmedabad, Bonn and São Paulo [26]

Chapter Summary

Urban climate action plans (UCAPs) guide cities in identifying key climate risks and in addressing climate change. Designed to guide urban transformation over decades through near-term and long-term actions reducing emissions and/or adapting to the consequences of climate change, UCAPs are intended to have significant impacts. Despite their significance for urban climate governance, the procedural quality of how UCAPs are created remains under-analysed.

By analysing UCAPs of four cities from different regions of the world - Accra (Ghana), Bonn (Germany), São Paulo (Brazil), and Ahmedabad (India) - we unpack the quality of UCAP creation processes in terms of their legitimacy including whether and how key stakeholders were involved in shaping the plan. Drawing on 72 semi-structured interviews with actors involved in the plan-creation process and complemented by document analysis, this study conceptualises UCAP creation phases and assesses its quality using the framework of input, throughput, and output legitimacy. In terms of key actors, this study highlights the crucial role city networks played in designing and funding UCAP creation processes. Significant differences in UCAP legitimacy with regards to levels of co-production, transparency, accessibility, and substantive participation across the case studies are shown. Based on these findings this study provides actionable insights for the creation of legitimate and impactful UCAPs to promote just and equitable urban transformations.

4.1 Introduction

Cities play a significant role in achieving global and national climate change goals while also addressing local development priorities. Already today cities are responsible for over 70% of CO_2 emissions while being especially vulnerable to the consequences of climate change (Adelekan et al., 2022; IPCC, 2018a, 2022; Mahendra et al., 2021). As these trends will aggravate given that an estimated 2.5 billion people will be added to cities by 2050, cities are at the forefront of combatting climate change (Adelekan et al., 2022, p. 28; Revi et al., 2022).

For planning the transformation towards climate-resilient and low-emission cities, urban climate action plans (UCAPs) are of pivotal importance. Integrating knowledge and policy on the main sources of climate change and/or local vulnerabilities as well as the related response options to address these, UCAPs are documents summarising the intentions of cities in how they plan to mitigate and/or adapt to climate change (Deetjen et al., 2018; Pietrapertosa et al., 2019; Reckien et al., 2018)[27]. Studies suggest that thousands of cities have initiated some form of planning with many more likely to follow within this decade (Aboagye & Sharifi, 2023; A. Otto et al., 2021; Reckien et al., 2018; Salvia et al., 2021; UN-Habitat, 2015)[28].

As UCAPs have been set to determine municipal policies across all sectors for decades, they will affect a large proportion of the global population (Dodman et al., 2022; Kato-Huerta & Geneletti, 2023). However, given limited resources for local climate governance, UCAPs inevitably prioritise certain climate actions over others, potentially leading to unintended environmental, economic, and distributive consequences (Fitzgerald, 2022; Kato-Huerta & Geneletti, 2023). For instance, efforts to address climate change through urban greening initiatives or phasing out old vehicles can inadvertently increase housing and transportation costs disproportionately impacting those anyways already more vulnerable (Colenbrander et al., 2017; Sharifi, 2020). Thus, UCAPs should not merely focus on planning urban transformations, but should ensure that such transformations are equitable and just (Henrique & Tschakert, 2021; S. Hughes & Hoffmann, 2020; Mabon et al., 2024)[29].

Planning just urban transformation requires procedural quality, a recognition that has led to increased attention paid to the design of UCAP creation processes (Andonova et al., 2009; Feldman, 2012; Leal & Paterson, 2024). The literature examining UCAP processes has primarily focused on three key aspects: The participatory creation of UCAPs (Dekker, 2018; Mills & Futcher, 2021; Trundle & McEvoy, 2017), their inclusivity (Chu et al., 2016; Luna-Galván et al., 2017) and 'knowledge co-production' (Hölscher et al., 2024; Satorras et al., 2020; Swanson, 2023) [30].

Although these studies have highlighted the benefits of participatory or co-production approaches over linear, non-participatory processes, they often overlook the potential risks associated with UCAP co-production (Turnhout et al., 2020). However, experience shows that inadequate or poor implementation of participatory processes can contribute to what could be called an 'unjust urban transformation' (Hölscher et al., 2024; Munoz-Erickson et al., 2017; Ruiz-Mallén, 2020; Wamsler et al., 2020). Some authors have called

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[27] UCAPs comprise city's mitigation, adaptation or mitigation and adaptation plans.

[28] For instance, Salvia et al. (2021) analysed 885 cities in the EU-28 with a UCAP, while Reckien et al. (2018) examined 200 urban areas across 11 European countries with a UCAP. In Germany alone, Otto et al. (2021) found that 103 out of the 104 largest cities have mitigation plans.

[29] In this project we speak of (just) urban transformations to account for a deeper, more radical shift that goes beyond incremental changes or a simple transition from one state to another which could be implied by instead of just urban transition, acknowledging that terms are used often interchangeably in the literature (Torrens et al., 2021)

[30] UCAPs are increasingly co-produced, e.g. in Delhi (Lall et al., 2023), Barcelona (Satorras et al., 2020), Naples (Visconti, 2023), Bergrivier (Ziervogel et al., 2016).

to understand the role of power, politics and knowledge in governance processes towards just urban transformation (Cashmore, 2018; Munck & Lachmund, 2023; Späth, 2018; Turnhout et al., 2020).

Responding to this call, this paper explores the quality of UCAP creation processes to enable just urban transformation to move beyond conventional co-production or participatory planning processes by employing the concept of legitimacy. We understand legitimate UCAP creation processes as the procedural basis for just urban transformations and intend to analyse the legitimacy of UCAP creation processes. To do so, we assess the legitimacy of UCAP creation processes in five case studies across four cities – namely Accra (Ghana), Ahmedabad (India), Bonn (Germany) and São Paulo (Brazil) with investigating in Bonn the city-led and the civil society-led UCAP creation process based on 72 semi-structured interviews with policymakers, knowledge holders, city network and civil society representatives and community members.

The remainder of this paper is structured as follows. The next section introduces the conceptual framework, which explores the role of legitimacy in UCAP creation processes and the criteria of input, throughput, and output legitimacy. Following this, we detail the research design and methods used to examine UCAP processes across the four case study cities. The results section presents an analysis of the legitimacy of each city's UCAP process, identifying key factors that influence procedural quality. In the discussion, we reflect on the role of city networks, the importance of local capacity, and the broader implications of legitimate UCAPs for fostering just urban transformations. Finally, we conclude with policy recommendations and practical insights for enhancing the legitimacy of UCAP creation processes.

By focusing on legitimacy, this paper advances the understanding of UCAP creation processes and offers a framework to support just and equitable urban transformations. Tailored for policymakers concerned with urban transformation and city network representatives, this research provides practical insights that can help enhance procedural quality, fostering accountability and inclusivity in urban climate governance.

4.2 Conceptual Framework

This section introduces the conceptual framework for analysing legitimate UCAP creation processes. It discusses the importance of legitimate UCAPs for enabling just and equitable urban transformation and outlines criteria of input, throughput, and output legitimacy for providing a structured approach to evaluating UCAP legitimacy.

Legitimate UCAP Creation for Enabling Just Urban Transformation

In light of climate change and related mitigation and adaptation actions, cities all over the world are set to change fundamentally within the next decades (Adelekan et al., 2022; Revi et al., 2022). This transformation will increasingly be guided by the process, ambition, and implementation of UCAPs (Deetjen et al., 2018; Pietrapertosa et al., 2019; Reckien et al., 2018).

Initially, UCAPs focused predominantly on mitigating greenhouse gas emissions from „end-of-pipe" sources, reflecting a narrow emphasis on technical solutions to reduce emissions (Bulkeley, 2010; Geneletti

& Zardo, 2016). However, since the 2015 Paris Agreement and the completion of the IPCC's Fifth Assessment Cycle, there has been a notable shift toward integrating adaptation measures into these plans (Aboagye & Sharifi, 2023, 2024). Despite this progress, UCAPs often inadequately address equity and justice, overlooking the disproportionate impacts of climate actions on vulnerable populations (Finn & McCormick, 2011; Fitzgerald, 2022; Kato-Huerta & Geneletti, 2023; Reckien et al., 2023).

This lack of equity and justice addressed in UCAPs points to the importance of their creation processes. In these processes both political interests and knowledge are integrated, encompassing the interests of included stakeholders such as policymakers from different levels of governance, civil society or business representatives and citizens for instance. These interests are integrated with different forms of knowledge, including global science about the physical base of climate change and scientific and other local knowledge about mitigation and adaptation options.

Given the scale of the transformations required for addressing the climate crisis in cities, it can be argued that this transformation should be carried out in a just and equitable manner (Henrique & Tschakert, 2021; S. Hughes & Hoffmann, 2020; Torrens et al., 2021). To enable just urban transformation, this paper argues that legitimate UCAP creation processes can form a sound procedural basis. Adopted from political philosophy, where legitimacy is often viewed as the enabler for just outcomes (Christiano, 2004; Habermas, 1971; Pettit, 2012; Rawls, 2005), this paper views legitimate UCAP creation processes as the enabler for just urban transformations[31]. We hence understand legitimacy to enhance UCAP creation processes by improving both inclusivity and epistemic quality. Inclusivity in this regard is understood as including diverse stakeholders within the UCAP creation ensuring that they substantially participate (Al-Humaiqani & Al-Ghamdi, 2022; Cambridge Dictionary, 2024); epistemic quality refers to the extent to which knowledge is considered holistically for the UCAP to be built upon a credible base.

Through enhancing the inclusivity and epistemic quality of UCAPs through legitimate creation processes, it is also expected that their effectiveness is increased – legitimate UCAPs are more likely to be implemented (Cashmore & Wejs, 2014; Eneqvist et al., 2022; Growe et al., 2020). Studying UCAPs, Cashmore & Wejs (2014) and Klein et al. (2016) found that legitimacy is key for the prioritisation within local administrations. Hence for UCAPs to become implemented they suggest that legitimacy itself could be instrumental in ensuring the effectiveness of UCAPs (Cashmore & Wejs, 2014, p. 211).

Criteria of Legitimacy for UCAP Creation Processes

Following the legitimacy literature, UCAP legitimacy is conceptualised as 'input, throughput, and output legitimacy'. Input-legitimacy criteria assess the quality of participation and holistic knowledge integration in UCAP creation and results from the responsiveness to citizens' concerns as a consequence of participation *by* the people. Output legitimacy is about the effectiveness of the UCAP *for* the people (Schmidt, 2013, p. 2) and hence is its ability to foster the climate action laid out in the UCAP. UCAP throughput-legitimacy relates

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[31] Legitimacy in this paper is understood in a procedural way and hence resembles characteristics of concepts such as 'procedural justice' and 'procedural equity'.

to all procedural aspects of how the UCAP interest and knowledge inputs are transformed into outputs (U. Beck & Zürn, 1998; Schmidt, 2013; Steffek, 2015).

For making this conceptualisation of UCAP legitimacy into 'input', throughput' and 'output' legitimacy actionable, this paper adopts the criteria of an integrative literature review on processes integrating knowledge and policy in the sustainability context of Wagner et al. (2024). This framework is chosen because it offers actionable criteria for conceptualising the legitimacy of knowledge policy creation processes in different sustainability contexts across scales and geographies and hence was suitable for assessing legitimacy within local climate action plan processes[32]. From this framework 13 criteria useful for answering the research question of this study are briefly introduced in the following and are illustrated in Figure *10*.
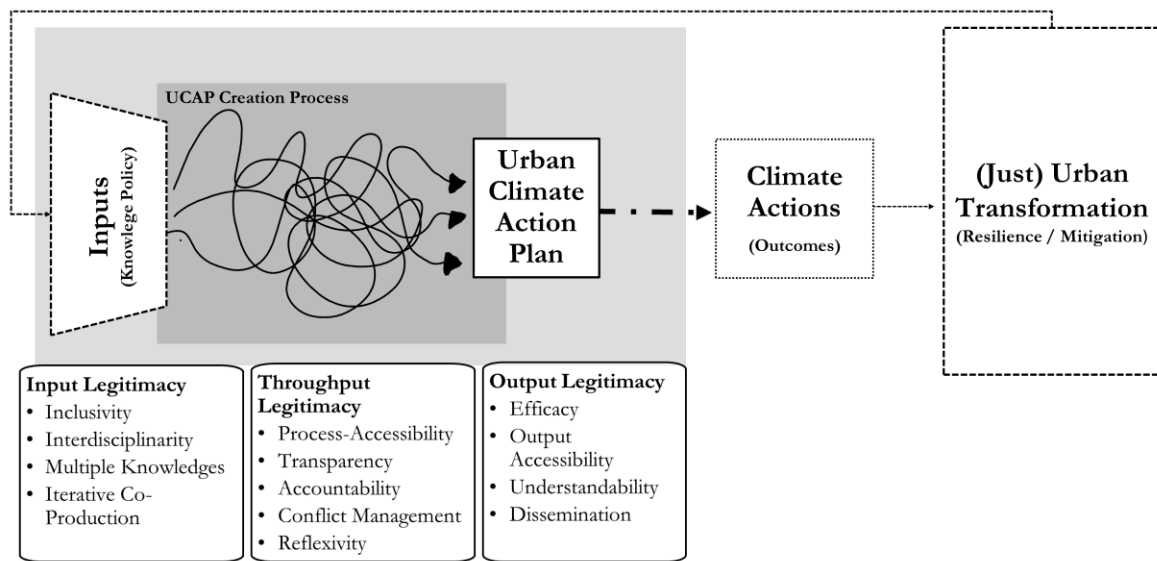
Figure 10: Criteria of input-, throughput- and output legitimacy adopted from Wagner et al (2024)

Assessing the quality of participation and holistic knowledge integration in UCAP creation, input-legitimacy criteria include the inclusive participation of policymakers, politicians, civil society organisations, citizens and other affected stakeholders while holistic knowledge integration includes various knowledge systems and interdisciplinary scientific knowledge. Iterative co-creation, indicating continuous interaction between policymakers and knowledge holders to jointly produce the UCAP, captures the aim of integrating knowledge and policy (J. M. Chambers et al., 2021; Wyborn et al., 2019).

Criteria of throughput legitimacy comprise the accessibility for enabling substantive participation of stakeholders, transparency of participants' selections and the process of writing the UCAP transparently, conflict-management and accountability mechanisms as well as reflexivity about possible power imbalances between participants and measures for mitigating those (N. Wagner et al., 2024). Criteria of output legitimacy

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[32]. While the framework was exemplary applied to knowledge-policy institutions at the global level, namely the Intergovernmental Panel on Climate Change (IPCC) and the Interstate-Platform on Biodiversity and Ecosystem Services (IPBES), the framework is designed to enhance the legitimacy of process in the sustainability context at all levels.

include efficacy and hence how tailored the UCAP is to the city, accessibility, understandability and dissemination (ibid.).

Grounded in criteria of input, throughput, and output legitimacy, this framework is expected to offer a valuable lens to critically examine and enhance the legitimacy of UCAP creation processes by elucidating dynamics of how knowledge is integrated into urban climate policymaking.

4.3 Research Design and Methods

This section outlines our approach to examining the legitimacy of UCAP creation processes across four cities. We employ a qualitative comparative case study method, utilising semi-structured interviews and document analysis. The following subsections detail our case selection, describe our data collection methods, and explain our analytical approach.

Case studies

This study analyses the UCAP creation process of four cities, namely Accra (Ghana), Ahmedabad (India), Bonn (Germany), and São Paulo (Brazil). In addition to being classified to being classified as cities according to UN-Habitat (UN-Habitat, 2024), in all of the study locations at least one UCAP in the last five years has been developed. Further, the selected cities are located in a democracy. Being members of a network of climate-ambitious cities or 'mitigation forerunners' (Leal & Paterson, 2024; A. Otto et al., 2021), all four cities have the potential to lead by example in their respective geographical contexts. The accessibility to potential interviewees was also an important selection criterion with the four research locations being chosen given that the research was embedded in a larger research project with partner institutions in each city. With this selection, we aim to balance comparability and variety of the case study location with the feasibility of conducting study.

Five UCAP creation processes were analysed across four cities. Bonn developed two separate UCAPs in parallel, one by the city administration and one by a civil society organisation called 'Bonn im Wandel'. While these two plans in Bonn were merged to some degree after completion, during the research it became evident they were two separate processes which hence need to be considered as such. The final selection comprises:

- Accra Climate Action Plan, Accra, Ghana (AMA, 2020)
- Ahmedabad, India (AMC, 2023)
- Klimaplan 2035 Bonn, Bonn, Germany - City-led UCAP (Stadt Bonn, 2023)
- Bürger*innen Klima-Aktionsplan Bonn, Germany - Civil society-led UCAP (Bonn4Future, 2022)
- Plano de Açao climática do municipo de São Paulo, São Paulo, Brazil (Secretaria de Governo Municipal, 2022)

We acknowledge that the creation of UCAPs is not independent of the economic and governance context within which they fall nor of the international political economy. With regards to the resources available for

planning climate action, for instance, it is noteworthy that GDP per capita in Germany is about four times higher than in Brazil and 10 times higher than in Ghana (World Bank, 2008)[33].

With regards to the level of autonomy cities have in deciding about having climate action plans or not, there are significant differences to be noted. For instance, constitutionally, the political system in Ghana is much more centralised with the national level determining local decision-making (Mohammed, 2022). In Germany and Brazil, by contrast, decision-making power is much more separated (Bäumer & Kroës, 2016; Rodrigues, 2018). In India, several urban planning decisions are under the purview of the state governments (Idiculla, 2020). While these contextual factors do not directly determine the legitimacy of UCAP creation processes, they provide crucial background for understanding the diverse challenges and opportunities each city faces in developing its climate action plans because these factors can influence the resources available for stakeholder engagement, the breadth of expertise that can be drawn upon, and the political landscape within which climate action must be negotiated.

City Name	Local Government	Country/Region	City Population[34]	Political System	National GDP per capita (PPP 2022) (USD) [35]
Accra	Accra Metropolitan Assembly (AMA)	Ghana / Africa	0.284 Mio (Greater Accra 5.5Mio)	Unitary presidential constitutional democracy	6473
Bonn	Stadt Bonn	Germany / Europe	0.336 Mio	Federal parliamentary republic.	66616
São Paulo	Prefeitura de São Paulo	Brazil / South America	12 Mio.	Federal presidential constitutional republic.	17827
Ahmedabad	Ahmedabad Municipal Cooperation	India / Asia	8 Mio.	Federal parliamentary democratic republic.	8400

Table 8: Overview of the four case study cities

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[33] An overview of these contextual factors is found in Table 1.

[34] (Bundesstadt Bonn, 2022; GSS, 2021; IBGE, 2022; Vasudha Foundation, 2022)

[35] (World Bank, 2024)

Data Collection and Analysis

Data Collection Methods

Our study primarily relied on two complementary data sources: semi-structured interviews and document analysis. The cornerstone of our data collection effort was a series of in-depth interviews conducted with key stakeholders involved in the UCAP creation processes across our four case study cities. From February to December 2023, the first author conducted a total of 72 semi-structured interviews, engaging with a diverse array of participants who played crucial roles in shaping their respective city's climate action plans (see Appendix II for a complete list of interview partners)[36]. We began with a review of each city's UCAP and related online resources, identifying individuals mentioned in acknowledgements, members of steering committees or working groups, and representatives from organisations cited as contributors. This initial scan provided us with a foundational list of potential participants. We then employed a snowball sampling technique, asking our initial interviewees to recommend other significant actors in the UCAP process (Naderifar et al., 2017).

In selecting our interviewees, we prioritised individuals with direct involvement in or significant knowledge of the UCAP creation process. We strived to achieve a balance across different stakeholder types and, to the extent possible, maintain gender diversity among our participants. We aimed to capture a wide spectrum of perspectives to ensure a comprehensive understanding of each city's UCAP development. Relative to representatives from policymaking, depending on the involvement from different levels of policymaking, and city networks, fewer interviews have been conducted with stakeholders from knowledge institutions, citizens, civil society or the private sector given the fact that overall they have had less important or even no role in the processes.

The interviews were conducted in-person and online, depending on the interviewee's location and preference. The first author is fluent in English, Portuguese, and German, allowing to conduct interviews in the participants' preferred language. After participants consented to their participation in the study, interviews typically lasted between 45 to 60 minutes with some significant variation[37]. Conditional upon participants' consent, interviews were audio-recorded and later transcribed and non-English interviews were transcribed with the help of AI, being carefully reviewed by the team members.

Our interview structure was guided by the conceptual framework introduced in section two, focusing on three key areas: the role of knowledge and knowledge-policy collaboration in the UCAP creation process, criteria of legitimacy in knowledge-policy interactions, and enablers and barriers for legitimate UCAP creations. The interview questions were specifically developed for this research, with adaptations made before each interview to ensure they were context- and stakeholder-specific. While we maintained a consistent core of questions across all interviews, we tailored our approach to each participant's specific role and expertise. Importantly, our semi-structured format allowed flexibility for interviewees to explore

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[36] Under the registration code '14c_22 Niklas Wagner', this study received ethical approval on 27.04.2022.

[37] The shortest interview lasted less than 10 minutes while the longest was more than three hours.

themes they deemed significant, potentially uncovering important aspects we hadn't explicitly addressed in our questions.

To complement our interview data, we conducted a document analysis of the UCAPs themselves, and included documents interview participants referred to during the interviews as key texts that influenced the UCAP development. These included party manifests, public communications, and policy briefs related to the climate action planning process.

It is noted that in-person interviews contributed to establishing a relationship of trust between the researcher and the interview partners. We acknowledge that the first author's whiteness certainly opened some doors. While certainly many doors were opened, some remained closed: Many more stakeholders than the 74 interview partners have been approached but declined the request or did not allow a recording. Additionally, we recognize that some nuances may have been lost in the translation of interviews not conducted in English.

Data Analysis

Our data analysis process employed a multi-step approach that combined inductive and deductive coding strategies, thematic analysis, and validation techniques. The analysis began by importing all interview transcripts and relevant documents into MAXQDA 2022 software. We then developed an initial coding framework based on our theoretical understanding of legitimacy in knowledge-policy interactions and UCAP creation processes. This framework was not static; rather, it underwent iterative refinement through team discussions and pilot coding of a subset of interviews employing an inductive-deductive approach (Boyatzis, 1998) and a constant comparison technique (Tesch, 2013) to identify emerging themes and continuously refine our coding structure.

The final coding structure encompassed several major categories, including the 13 legitimacy criteria, knowledge types and sources, stakeholder roles and interactions, barriers and enablers to legitimate UCAP creation, and context-specific factors. Our primary unit of analysis was the individual UCAP creation process in each city, allowing us to capture the unique characteristics and dynamics of each case. To ensure coding validity, multiple team members independently coded a subset of interviews. We held regular team meetings to discuss and resolve any coding discrepancies, using these sessions as opportunities to refine our coding framework and align our interpretations. This collaborative approach enhanced the consistency of our coding process.

We utilize the analysis tools of MAXQDA 2022 to conduct cross-tabulations of codes across case studies, gender and stakeholder types, enabling us to identify patterns and relationships within our data. Thematic analysis was performed to identify recurring patterns and themes both within and across cases.

4.4 Results

This section presents the findings of our study on the legitimacy of UCAP creation processes, focussing on the comparison between the five different processes[38]. To provide a comprehensive understanding of the legitimacy of UCAP creation processes, we first describe the UCAP creation process itself, followed by an analysis of its legitimacy

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[38] As hypothesised, cross-tabulation analysis across stakeholder types and gender the number of coded segments across the different codes being proportional to the number of interview partners pointing to no significant results to report in this regard.

Name of the UCAP (year of finalisatioN)	Process-Design Phase					Knowledge-Policy Interaction Phase			Finalisation Phase	
	1. Concrete Motivation	2. Funding	3. Process-Design			4. Problem Analysis – Vision Setting	5. Response Creation and Prioritisation	6. Response Priorisation	7. Citizens Assembly	8. Political Decision
			Main stakeholders	Template	Principles					
Accra Climate Action Plan (2020)	- Accra being a C40 city - Funding possibilities - National demands	BMUV (Germany) through C40	AMA, C40	C40	Inclusivity of Stakeholders	City Vision 2050 and inventory in a Stakeholder workshop	Co-creation with stakeholders	Prioritisation through multi-criteria analysis between stakeholders	Citizens Assembly for consultive purposes	Through council
Klimaplan 2035 Bonn (2020)	- Civil society pressure and following cities' climate emergency	City funding	Stadt Bonn, gertec and Jung Stadtkonzepte, WI	Gertec	No information	GHG Inventory created by city network organisations	Co-creation between CNO and city department	Not applicable	No	Through local council
Bürger*innen Klima-Aktionsplan (2020)		Citizens Engagement Project Funding through the City of Bonn	Bonn im Wandel (civil society)	Not used	Co-creation	City Vision 2035 in Citizen Stakeholder Format cocreated	Co-creation with Citizens Stakeholder workshop, prioritisation only partially happened	Not applicable	Not applicable	Considered by Municipality.
Plano de Acao climatica do municipo de São Paulo (2020)	- Municipality approached C40 given C40 Initiative	BEIS (UK) through C40	C40, Secretaria do Verde	C40	Cross-departmental collaboration.	GHG Inventory and Vulnerability Mapping by different knowledge institutions	Co-creation between various departments of the city and stakeholders	Not applicable	Citizens assemblies happened	Through municipality
Climate Resilience City Action Plan Ahmedabad (2023)	- Development project - International Commitments	Swiss Development Agency	Econcept, ICLEI and AMC (partially)	Capacities Project	No information	ICLEI vulnerability mapping and GHG inventory	Actions of previous cities tailored to Ahmedabad	No information	No information	No information

Table 9: Summary of the different stages of the five UCAPs

UCAP Creation Process

To understand the process of UCAP creation, we conceptually divide it into three phases and eight steps – the initial and design, the knowledge-interest integration and the finalisation phase. This framework systematically examines the process, from initial motivation to adoption and implementation. Figure 11 illustrates the three phases of UCAP creation, with Table *9* providing detailed summaries of the five processes examined in this study.
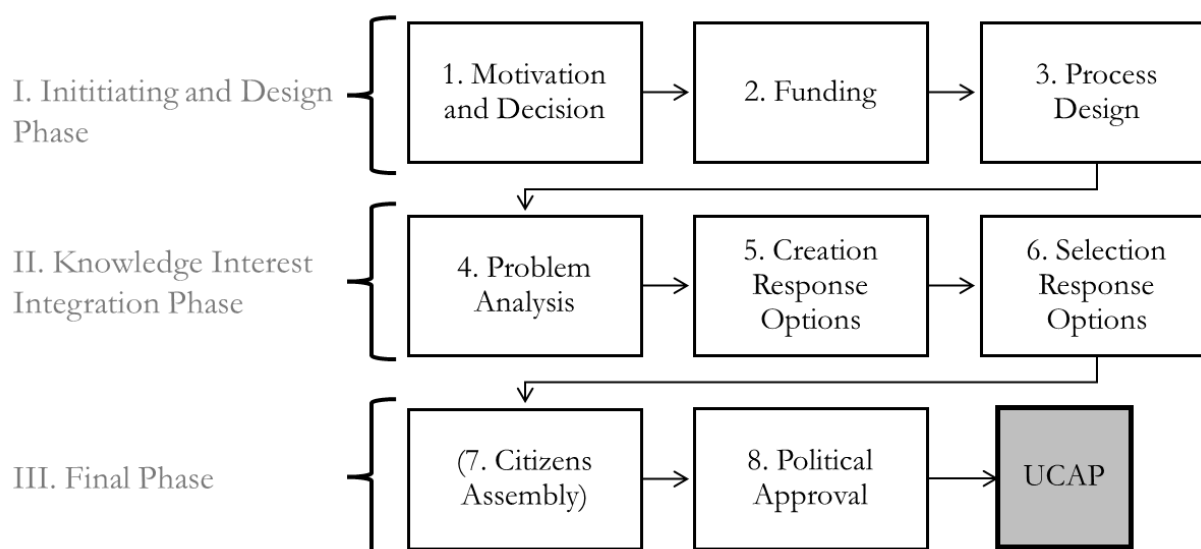
Figure 11: Three phases of UCAP creation

UCAP Process-Design Phase

The UCAP creation process begins with the initial motivation and design phase, which is deeply embedded in the political context of each city. This phase sets the foundation for the entire UCAP development process. In cities like Accra and Ahmedabad, national policy interests have played a significant role in shaping the UCAPs. For instance, Ahmedabad aligned its plan with the Government of India's goal of achieving net-zero emissions by 2070. In Accra, strong political support stemmed from the president's public commitment to make the capital „the cleanest city in Africa" (Daily Graphic, 2017).

The global context, particularly the Paris Agreement, has created a favourable environment for climate action in all study countries. This international commitment has prompted city network organisations to encourage their members to create UCAPs and has facilitated funding for these initiatives. For example, C40's 'Deadline 2020' campaign was the catalyst for São Paulo's UCAP creation (C40, 2020). In Bonn, civil society pressure led to the declaration of a climate emergency and subsequent UCAP initiations (Klimawache Bonn, 2019),

Funding for all five UCAP creation processes came from the Global North – despite three of the cities being located in the Global South: In Ahmedabad, the Swiss Development Cooperation funded the process,

in Accra it was the German Ministry for the Environment and in São Paulo the British BEIS ministry supported the creation process. Funding was channelled through the respective city network organisations.

City network organisations played a crucial role not only in funding but also in designing the UCAP creation process. Their past experiences in creating UCAPs worldwide provided valuable templates, especially for city-administration-led UCAPs. In Accra and Ahmedabad, the UCAP process was primarily designed by the respective city network organisations and their staff, who were integrated into the municipal structure. In Bonn and São Paulo, relevant departments designed the process with support from city network organisations[39].

Knowledge-Interest Integration Phase

Designed in the previous phase, in the knowledge-policy interaction phase of UCAP creation knowledge and policy are integrated. This phase of UCAP creation started with some form of problem analysis or vision setting. In all city-led climate action plans, greenhouse gas inventories to identify sectors with high mitigation potential were created and additionally, in all three Global South cities, a vulnerability analysis was undertaken. These tasks were partially outsourced to different knowledge institutions. In Accra and Bonn's civil society UCAP there was a positive vision of a future city created jointly by the involved stakeholders (AMA, 2020; Bonn4Future, 2022).

After problem identification and vision setting, the core of UCAP creation processes followed, identifying possible response options and prioritising them. Only in Bonn's civil society plan, the identification of response options was done from scratch, all other UCAPs are to some extent based on possible response options from the repertoire of their respective city network organisations. Exemplary for this is the 'Basket of Solutions', the response option repertoire of the actions considered in Ahmedabad (Capacities Project, 2020). In Bonn and São Paulo, options for climate action were co-created and prioritised mainly by the different departments of the city, complemented by some stakeholder engagement in São Paulo. In Accra, more than 100 actions were co-created between the stakeholders included in the process with 20 actions being prioritised in a multi-criteria analysis (AMA, 2020).

UCAP Finalisation Phase

The final phase of UCAP creation involves presenting the draft plan to citizens and gaining political approval. In São Paulo and Accra, this phase began by presenting a draft of the UCAP to citizens for information and consultation purposes (Interview 38, AMA 2020). Before implementation, UCAPs in the study areas have been politically adopted by the respective city councils, in Bonn and São Paulo in modified versions[40]. Across all study cases, the UCAP was described as the city's strategy for climate action. Most UCAPs focused on municipal climate action, with São Paulo's UCAP being unique in including a chapter on individual action for citizens.

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[39] Interviews 28,31,34,35,38,45

[40] Interviews 33,52

Legitimacy of UCAP Creation Process

Having established an understanding of the UCAP creation process, we now turn to analysing the legitimacy of these processes. This analysis is based on the conceptual framework presented in section two.

Input Legitimacy of UCAP Creation Processes

Input legitimacy in UCAP creation processes encompasses several overlapping criteria: inclusivity, multiple knowledge, interdisciplinarity, and iterative co-production (see Table 10).

Legitimacy Criterion.	Accra	Bonn Civil Society	Bonn Admin	São Paulo	Ahmedabad
Inclusivity	Explicit focus on inclusion of vulnerable stakeholders, intention on informal through civil society, town hall meetings, explicit gender focus missing. Private sector and political institutions included	Focus on citizens (100 randomly selected) and 25 stakeholders. Policymakers spoke as experts.	No participatory process external to the city administration	Focus on administrative level, core-stakeholder engaged. Citizen participation formats (town hall meetings) were used.	No information about the degree of inclusivity is available.
Multiple Knowledge	Inclusion of specific communities such as traditional chiefs and affected stakeholders such as waste collectors.	Local knowledge of citizens as „experts of living in the city"	Not applicable	Inclusion of stakeholders' knowledge of specific topics	Data collection through qualitative methods („Shared learning dialogues")
Inter- and trans-disciplinarity	Multiple disciplines included, informal inclusion „discipline-picking"	Experts from various sectors and disciplines included	In-house expertise interdisciplinary	Through broad inclusion of departments' intention of „transversality".	Different internal expertise within city network organisation, no formal external expertise
Iterative Co-Creation	Iterative meetings, formal and informal, between different stakeholders to co-produce the UCAP	Four fora bringing together citizens and experts, UCAP was created by citizens.	Partial co-creation by city network experts and city administration	Co-creation within city administration supported city network experts	Plan was mostly created by the city network organisation

Table 10: Input legitimacy criteria for five UCAP creation processes

Accra's UCAP creation process stands out for its focus on inclusivity. The process design principle emphasized integrating vulnerable communities, resulting in participation from a diverse range of stakeholders. These included political actors, university representatives, private sector representatives,

informal waste collectors, market women, and traditional chiefs. All these groups participated in numerous meetings to co-create the UCAP, jointly selecting solutions and creating a shared vision (AMA, 2020).

The inclusion of diverse stakeholders and their climate-related knowledge and its impacts contributed significantly to the input legitimacy of Accra's UCAP creation process. Notably, several universities and research institutions across the country contributed both formally and informally, despite the UCAP team not placing "too much premium on academic contributions" as the focus was on creating a "workable document for the local government, not an academic paper" (Interview 7). While experts from multiple disciplines contributed to Accra's UCAP, some gaps were noted. For instance, expertise in biodiversity and urban greening was not considered, and stakeholders such as the flower grower association were not invited[41].

Bonn's Civil Society UCAP was designed with a co-production intention. In four mini fora of each two days, 100 randomly selected citizens were invited as 'experts of living in Bonn' (Bonn4Future, 2022, min 15:30) to create a citizens' UCAP together with 25 representatives of initiatives, companies and institutions (Bonn4Future, 2022)[42]. These 125 participants came together with technical experts from policymaking and research to co-create a strategy towards carbon neutrality. Unlike the city-administration-led UCAPs, Bonn's civil society process began by co-creating a joint, positive vision of life in Bonn in 2035. This was followed by sessions on finding concrete actions for various sectors such as housing, culture and sports, and food systems. However, despite co-productive intentions, the project design was tailored towards citizens creating 'their' climate plan, with knowledge-holders and policymakers serving as consultants rather than co-creators. This approach is evidenced by the fact that policymakers were briefed about the results of the deliberations after each citizens-stakeholder forum, indicating that the UCAP was not fully co-created between policymakers, knowledge holders, and society, but rather represents a 'citizens' version' of a UCAP (Bonn4Future, 2022).

In São Paulo and Bonn's city administration, UCAPs were mainly created within the municipal administration, supported by their respective city network organisations. Additionally, in São Paulo, stakeholders from civil society, business and knowledge institutions have been consulted on specific topics, emphasising the 'transversal nature of climate action' throughout the UCAP and its creation (Interview 38). Further, São Paulo's UCAP stands out as next to motivating climate action through local and global science, artistic knowledge in the form of poems or song lyrics was used to 'emotionally engage the implementers' (Interview 38).

Given that parallel to Bonn's city administration UCAP the civil society organisation 'Bonn im Wandel' produced a citizen's plan, there were no own efforts for creating an inclusive UCAP by Bonns' city administration, relying on 'stitching both plans together at some point'[43]. With regards to both UCAPs in

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[41] Interviews 5, 6
[42] Interviews 33, 37
[43] Interviews 28,29,31,33,34

Bonn, it is noted that both were designed from the beginning as mitigation-centred plans without giving knowledge holders included in the plan the possibility to provide arguments for planning adaptation and mitigation together.

Similarly, Ahmedabad's UCAP creation was not designed in a participatory manner including various stakeholders and their demands and expertise but followed rather a linear model of knowledge–policy interaction: Ahmedabad's city network organisation conducted the problem analysis through a GHG inventory and a vulnerability mapping combining qualitative and quantitative methods and suggested actions from a given set of actions the city network have collected from other projects in the past[44]. While in some cases these 'solutions' have been selected with the respective heads of department of Ahmedabad Municipality[45], in other cases the heads of departments were not aware of their municipalities' climate action plan despite being mentioned as authors in it[46]. One interview partner said that including names by default is 'common government practice' (Interview 66). While this does not imply that their departments did not engage with the cities' plan-making team and did not provide them with data, for instance, it implies that the process had limited involvement of the local decision-makers.

Throughput Legitimacy of UCAP Creation Processes

Throughput legitimacy in UCAP creation processes relates to the accessibility, transparency, and reflexivity of the process itself (see Table 11). Accessibility varied across the different UCAP creation processes. In Accra, stakeholders from vulnerable communities faced significant challenges in attending meetings due to high transportation costs and the opportunity costs of missing a full day of work[47]. Participants in Bonn's civil society UCAP received a daily allowance to lower opportunity costs[48]. For this process, it was further highlighted that all locations were physically accessible as well for people with disabilities[49]. Additionally, there was the intention to use simple language and there was a simultaneous translation into the mother tongue of two participants whose language was not German[50].

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[44] Interviews 61, 62, 70

[45] Interviews 64,69

[46] Interviews 60,65,66

[47] Interviews 7, 15

[48] Interview 32

[49] Interview 35

[50] Interview 35

Legitimacy Criterion.	Accra	Bonn Civil Society	Bonn Admin	São Paulo	Ahmedabad
Accessibility	High opportunity cost for vulnerable stakeholders not covered.	Daily allowance paid for participating stakeholders, people with disability taken into account, simple language used, translation service, clear moderation rules	Not applicable	No information	Not applicable
Transparency Stakeholder Selection	No transparency, following the city network organisation's stakeholder selection format	Citizens are selected by lottery, snowballing for experts	No information	Intransparent process	No information
Transparency Writing Process	No information	Transparency of all submissions	No information	No information	No information
Reflexivity	No information	Power differences are acknowledged, and the intention of mitigation is through clear rules and moderation.	No information	Power differences acknowledged the intention of mitigation through moderation.	No information
Accountability or Conflict Management Mechanism	No information	No information	No information	No information	No information

Table 11: Throughput legitimacy criteria

Transparency as a criterion of throughput legitimacy was assessed in terms of the selection of stakeholders and the process of drafting the UCAP. With regards to transparency of stakeholder selection, information on how stakeholders have been selected was not written in the UCAP and was not publicly available for all city-administration-led UCAPs. Despite this, among political stakeholders designing the process, transparency was perceived to be high, or transparency did not seem to be a bigger concern captured well by this quote: 'Nothing was hidden from anybody. But not everybody was overloaded with information' (Interview 69). Rather than being driven by criteria selection of stakeholders was rather based on luck as a civil society representative in São Paulo said: 'We were lucky to be in the right place at the right time to be able to take part in the only workshop there was' (Interview 50).

In contrast, Bonn's civil society-led process used a lottery system with criteria such as age, gender, and educational background to ensure a representative selection of citizens. Additionally, 25 stakeholders from civil society were included based on predefined criteria, although the selection criteria for expert speakers remained unclear (Bonn4Future, 2022).

Transparency for the drafting process and hence the documentation of how the UCAP came about was overall less of a priority with information on this not publicly available on any site except for Accra. Here the UCAP includes a section on how all the stakeholders have applied a 'multi-criteria analysis' with the

criteria being documented (AMA, 2020). In the other locations, it might often have been the experts from the city network organisations who are writing and with this partially selecting some of the response options as captured in the following quote from an expert writing the UCAP in Bonn: 'So I don't want to say now that everything is completely immediately comprehensible and somewhere also now and then the gut of the expert decides and says come, we do that now. No, but I did not have the feeling that something was hidden somewhere or back there' (Interview 35).

To ensure the participation of all participants despite differences in their societal backgrounds, the importance of awareness and reflexivity among the moderation facilitating the process was highlighted as important[51]. While this awareness is important, the moderation of a stakeholder session in São Paulo pointed out the difficulty of usually more powerful stakeholders being better at talking and convincing, endangering the legitimacy of the process: 'I was facilitating that session alone, it was really hard because there was this lady from a big industry, and she was such a good talker' (Interview 45). No accountability nor mechanisms for conflict management for possible conflicts of interest, for instance, have been found.

UCAP Output Legitimacy

Output legitimacy of UCAP creation processes relates to the quality of the UCAP in terms of its ability to foster the climate action laid out in the UCAP. Output legitimacy focuses on how effectively the UCAP's content can be implemented. This implies considering the purpose and role of the UCAP and its target audience. As UCAPs are intended to guide municipalities towards climate neutrality (and resilience), the main audience of UCAPs is typically the staff responsible for implementation often located within the local administration.

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[51] Interviews 32,45

Legitimacy Criterion	Accra	Bonn Civil Society	Bonn Admin	São Paulo	Ahmedabad
Efficacy	Funding problems	Critique that action suggestions beyond municipal responsibility	Needed to be adapted by the city administration	No information	No information
Output Accessibility	On website accessible	On website	Accessible on the website, but difficult to navigate	Accessible on website	Not published at time of research
Understandable	Simple English, clear	Yes (but long with 400 pages)	Critique of being rather technical	Focus on understanding city administration and emotionally convincing through art.	No information
Dissemination	Active media engagement	Limited dissemination through media, different formats (Summary and small brochure	Featured in the city administration podcast	Through the city's social media records	Not applicable

Table 12: Criteria of output legitimacy

One criterion of output legitimacy is efficacy understood as 'the extent to which the output fits the problem at hand, and is relevant for solving it effectively' (Mena & Palazzo, 2012). In Bonn, one stakeholder responsible for implementation raised this issue of reduced efficacy. Speaking about the city network organisations developing the UCAP for Bonn he said „They have a very broad municipal experience. Nevertheless, the result was a large work with seven main topics, ranging from the economy to mobility and so on, where it became clear that they are not quite in the depths of Bonn's reality as far as the administration is concerned" (Interview 29). This lack of efficacy points to a lack of co-production showing how input legitimacy is linked with output legitimacy.

In terms of output accessibility, all UCAPs, except Ahmedabad's unpublished plan, are available online (March 2024). With the main target group being the city's implementing staff, the UCAP has to be understandable for them to be able to implement the actions. In Accra, stakeholders particularly praised the implementation plan for its high understandability, attributing this to its simple language and concise length - especially when compared to more extensive documents like Bonn's 400-page plan [52]. In the Indian context, it was pointed out that regional languages might improve understandability, while in São Paulo poems and art have been used to make the document not only technical but to emotionally involve the implementing stakeholders[53].

Efforts to disseminate the UCAP to the wider public varied. São Paulo and Accra held consultative citizens' assemblies, and there were media and social media engagement efforts in Accra, São Paulo, and Bonn. While

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[52] Interviews 4,6,7,12,21, 31

[53] Interviews 38,54

all UCAPs in this study were produced as documents, a city network official mentioned other UCAPs that had also been produced in poster format for the offices of the implementers[54].

4.5 Discussion

The Multiple Roles of City Networks in UCAP Creations

Our findings on the significant roles of city networks in UCAP creation processes align with and build upon the body of literature on transnational municipal networks in global climate governance. City networks play several key roles in UCAP creation processes, including motivation and funding, process design, and knowledge dissemination.

In São Paulo, Accra and Ahmedabad, city networks had critical roles in the initial motivation for creating the UCAP and organising the respective funding, channelling the demands of the funder towards the city as an interview with a stakeholder from a Swiss development consultancy about the Swiss-funded UCAP of Ahmedabad showed. Partnering with the city network ICLEI, this consultancy provided the capacity training to ICLEI ("we train the trainers") as well as the focus of the UCAP design process was designed around the 'basket of solutions' found in previous projects with an explicit focus on mitigation without the intention to be very participatory (Interview 61, memory log). Without Swiss funding, it is likely that the UCAP would not have been created.

In all four city-administration, UCAPs city networks further assumed an influential role in designing how policymakers and knowledge holders come together to create the UCAP. Further, city networks have important knowledge roles: They create their knowledge and translate global knowledge for their members, they organise capacity training and visits as well as their network function has an important knowledge role of sharing best practices and learnings about specific topics related to sustainability[55]. 'C40 was in fact who had the knowledge and was pulling the strings of the work, so C40 was the financing agent of the plan, it was C40 that did the coordination and the work with the city, helped in the discussions, brought in experts from outside to talk about certain topics, to broaden the discussion' (Interview 44). It should also be noted that city network-led plans could result in a 'repeat menu' of actions from their experience in contrast to fresh and creative locally relevant ideas that could be generated through a more participatory process.

These multiple roles city networks assume make them very powerful actors for UCAP design processes and hence important for fostering local climate action. However, it should be noted that several stakeholders perceive the significant role of city networks in local climate action planning as a reproduction of post-colonial tendencies[56]. One stakeholder in India summarised it very drastically that UCAPs are 'Western ideas funded by Western money not wanted by the local authorities' (Interview 58). In contrast to Ahmedabad,

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[54] Interview 45
[55] Interviews 7,44,45,55, 62,70
[56] Interviews 5,38,54,58

in São Paulo various stakeholders underlined the very pivotal but supportive role of the city network the local UCAP was co-produced with[57]. This tension between being a pivotal actor in climate action on the one hand and the risk of reproducing post-colonial tendencies has been previously identified in the literature (Bansard et al., 2017; Barbi & de Macedo, 2019; Haupt et al., 2019).

Building on this research, future studies could further explore how city networks navigate conflicts of interest between organisational goals and the specific development needs and climate ambitions of host cities. Additionally, investigating the long-term impacts of network-led UCAPs on local capacity building and climate action implementation could provide valuable insights for improving the effectiveness and equity of these collaborative efforts.

Lack of Local Capacity and the Importance of Local Agency

The important role of city networks in the UCAP creation process might be related to the lack of capacity and resources within local administrations for planning and implementing robust climate action reports across all case studies[58]. Respondents pointed to shortages of trained personnel, limited financial resources, and competing priorities as major challenges hindering cities' ability to develop and operationalise comprehensive UCAPs. This lack of capacity was particularly pronounced in cities in the Global South, where resource constraints and capacity gaps were more severe and might be worsened if city networks just filled a vacuum for creating the UCAP without building up local capacity (Carter et al., 2015; Grafakos et al., 2020; Reckien et al., 2018).

While with general capacity constraints, the local agency of individuals has made a difference. In Accra, it was the mayor's deeply rooted desire for an inclusive process which led vulnerable communities to have a seat at the table Bonn's civil society UCAP was only possible because active individuals had a vision of a co-produced citizens' climate action plan [59]. In São Paulo, the role of particularly one individual in the city's administration has been pivotal for the complete UCAP process from the initial motivation to the final layout[60]. In all cases, local agency and individual ownership have contributed to the UCAP.

The Importance of Legitimacy for Enabling Just Urban Transformation

Legitimacy is crucial for integrating diverse forms of knowledge, including academic, local, and artistic perspectives, to enhance UCAPs. While in Accra the inclusion of academics demonstrated the potential for creating synergies between scientific and policymaking realms through the active involvement of researchers, in the other four case studies little academic engagement has been found. Beyond scientific knowledge, our findings underscore the significance of incorporating local knowledge and expertise, as well as the power of art in communicating emotions and experiences related to climate change. By embracing a

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[57] Interviews 38,47,48,53
[58] Interviews 21, 26, 29, 33, 42, 70
[59] Interviews 13,15,26,32,35
[60] Interviews 38,44,43,45,47,52,53,56

wide range of knowledge sources, UCAPs can better reflect the diverse realities and needs of urban communities, ultimately enabling more holistic and impactful climate action.

To mitigate the risk that UCAPs are perceived to be 'unwanted by local authorities' (Interview 58), legitimacy in the creation process is pivotal: In Ahmedabad, many actors pivotal for implementation did not know about the plan nor its content[61], several other stakeholders voiced concerns that 'it might be one of many plans which soon might be on the shelf'[62]. If co-created in a participatory process involving citizens, civil society representatives and policy makers within the city administration as well as criteria of throughput and output legitimacy being fulfilled, UCAPs are expected to be better anchored within the local administration and the broader public. Our findings hence mirror the findings of Cashmore & Wejs (2014) showing that legitimacy is important for UCAPs to be implemented and to outlive possible democratic changes in political authority.

However, not only in terms of increasing the likelihood of UCAPs actually being implemented UCAP legitimacy is important but also for contributing that this implementation is just. With fewer female stakeholders having been involved in the UCAP creation process of Accra, it was acknowledged that this lack of gender inclusivity led to the fact that no gender assessment had been carried out, possibly increasing the disproportionate effects of climate change for women[63] (Interview 6, 22) (Denton, 2002; Pearse, 2017). On similar veins it was mentioned in the same UCAP creation process that due to political reasons the opinion of an expert on biodiversity and climate change was not heard nor the local flower grower association was invited, leading to Accra's UCAP having less emphasis on urban green spaces[64]. It is reasonable to expect that engaging all these stakeholders would enhance legitimacy and could result in a more legitimate plan.

4.6 Conclusion and Policy Recommendations

This study has provided a critical assessment of the legitimacy of UCAP creation processes across four cities - Accra, Bonn, São Paulo, and Ahmedabad. By developing a framework of UCAP input, throughput, and output legitimacy, our findings suggest that legitimacy is not only crucial for ensuring inclusive and participatory processes but also for fostering the epistemic quality necessary for enabling effective urban climate governance. With this we provide an in-depth understanding of the importance of legitimacy for bringing together knowledge and policy to foster climate action, arguing that legitimacy can help mitigate the risks associated with co-production, which, without transparency, accessibility, reflexivity, and accountability, may inadvertently reinforce existing power imbalances (Turnhout et al., 2020).

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[61] Interviews 60,65,66

[62] Interviews 55, 58,59,70

[63] Interview 6, 22

[64] Interviews 5, 14

Thereby the article contributes to the literature on legitimacy, knowledge-policy interaction and urban climate planning processes. Specifically, the research presented conceptually contributed to this literature by providing a framework of UCAP input, throughput and output legitimacy which can be used to bring knowledge and policy together in urban climate governance. This legitimacy framework presented here comprises 13 criteria including criteria of inclusivity and co-production but addresses the associated risks through 'throughput legitimacy criteria' such as transparency, accessibility and reflexivity. In contrast to much of the literature focusing on the effectiveness of urban climate mitigation and adaptation measures (Addis et al., 2022; Hochachka et al., 2022; Setiadi, 2018), this paper's focus on legitimacy aims to enable just urban transformations that go beyond addressing the 'low-hanging fruits' of uncontroversial climate change mitigation and adaptation measures.

Empirically, the contributions lie in providing an understanding of the processes of UCAP creation and the extent to which criteria associated with legitimacy can be fulfilled in creating this climate planning. While the selected case studies represent a range of geographical, economic, and political contexts, the comparative analysis focuses on identifying the underlying mechanisms and cross-cutting themes that shape the legitimacy of UCAP creation processes. By examining the extent to which legitimacy criteria are met across these diverse settings, the study provides insights into the universal as well as context-specific factors that influence the procedural quality of urban climate action planning.

Further the study contributes to the literature showing that city networks have emerged as central actors in the design and funding of UCAP creation processes, often providing technical expertise and templates for cities (Barbi & de Macedo, 2019; Frantzeskaki, 2019). However, while their involvement may contribute to cities creating UCAPs, there is a risk that external funding and frameworks may not necessarily enhance local agency with this risking to foster just urban transformation. To prevent this it is recommendable for city networks operate in a way that empowers local stakeholders and ensures that climate action plans are tailored to the unique socio-political contexts of the cities they serve (Chu, 2016). The action guide in Appendix I serves as a practical tool for city officials and city network actors, providing operational insights into enhancing the legitimacy of UCAP processes.

While legitimate processes are foundational for just urban transformations, they are not enough in isolation. The successful implementation of UCAPs depends on a broader alignment of political will, financial resources, and institutional capacity (Aboagye & Sharifi, 2023). Cities, particularly in the Global South, face acute resource constraints, which can hinder the operationalisation of ambitious climate goals despite having legitimate and well-designed plans.

In conclusion, this paper contributes to the literature by offering a legitimacy-centred framework for assessing UCAP creation processes, which can guide policymakers in designing more inclusive, transparent, and accountable climate action plans for enabling just urban transformations. Given that there is no one-size-fits-all blueprint for just and equitable urban transformations, legitimate UCAP creation processes can form the procedural foundation for guiding such efforts.

CHAPTER 5: UNLEARNING MODERNITY & THE IPCC

5. Unlearning Modernity? A Critical Examination of the Intergovernmental Panel on Climate Change (IPCC) [65]

Chapter Summary

Modernity's ideals of progress through industrialisation, coupled with rationalist views of value-free and neutral science guiding policymaking, have been driving forces behind the climate crisis and related injustices. Post-colonial scholarship calls for unlearning this modernist paradigm. This study examines the extent to which the Intergovernmental Panel on Climate Change (IPCC), the preeminent global authority on climate change knowledge, is both shaped by the procedural logic of Eurocentric modernity and the tendencies towards unlearning these modernist characteristics in favour of more pluralistic, co-productive approaches.

Through an inductive-deductive qualitative methodology, including semi-structured interviews with IPCC authors and policymakers at international climate conferences, this paper finds the IPCC to be situated in a tension field between modernity and unlearning it. On the one hand, the IPCC is constrained by path-dependencies of Eurocentric modernity, manifested in the linear model of knowledge transfer, the differentiated systems logic of science and policy spheres, and the privileging of Western scientific expertise as universally valid and apolitical. On the other hand, the study also identifies emergent tendencies within the IPCC towards broadening disciplinary diversity, incorporating alternative epistemologies like Indigenous and Local Knowledge, and fostering co-productive collaborations between scientists and policymakers. These nascent 'unlearning' efforts signal cracks in modernity's edifice, though limitations and potential risks caution against overstatement.

By highlighting this critical juncture, the paper contributes empirical and conceptual insights into the IPCC's transition from modernist constraints towards more pluriversal climate responses. This analysis sheds light on the IPCC's evolving role in shaping global climate governance and the ongoing struggle to redefine climate knowledge production.

5.1 Introduction

Eurocentric modernity and its ideals of progress have been a driving force behind the climate crisis and related injustices. The worldview of human domination over nature coupled with the carbon-intensive paths of development through industrialisation and urbanisation is linked to increasing global average temperatures and related adverse consequences (Aquino, 2020; Chakrabarty, 2007, 2009; Domingues, 2022). Procedurally integral to the ideals of modernity is the linear interaction between science and policy (Harding, 2008; Latour, 1993b; Proctor, 1991). In this model, science is perceived as an autonomous realm capable of producing universal, value-free knowledge to guide policymaking through a one-way transfer, reinforcing a strict boundary between the realms of scientific „truth-speaking" and political decision-making (de Pryck & Wanneau, 2017; Turnhout et al., 2013).

Within this complex landscape of science-policy interactions, the Intergovernmental Panel on Climate Change (IPCC) has emerged as the preeminent body of knowledge guiding global climate policy (Edenhofer et al., 2024; Lidskog & Sundqvist, 2022b). Established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organisation (WMO), this panel is responsible for assessing the state of scientific knowledge on climate change, its impacts, and potential mitigation and adaptation strategies relevant for all levels of policymaking (Agrawala, 1998b, 1998a; IPCC, 2021; Skodvin, 2000). Operating through a systematic review process, it has produced six full assessment reports (AR1 to AR6) and 14 special reports (SR) on various aspects of climate change since its inception (Jones, 2013; Livingston, 2022). Assessment reports are composed of three separate reports on the physical base of climate change (Working Group I, WGI), the impact of climate change and ways of adaptation (WGII) and mitigation strategies (WGIII) (Livingston, 2022). By its intergovernmental nature, the IPCC brings together thousands of scientists as well as all countries members of the United Nations or WMO and it is often considered the leading scientific authority on climate change (Kouw & Petersen, 2018; Mahony, 2022).

With its importance and prominence, the IPCC has become an important object of study in the Science and Technology Studies (STS) and environmental governance literature (Hulme & Pryck, 2022; O'Reilly et al., 2024; Wagner et al., 2023). Topics of the IPCC literature include, among others, the boundary work of the IPCC (Guston, 2001; Lahn, 2022; Lahn & Sundqvist, 2017; Lidskog, 2024), models of knowledge-policy interaction knowledge represented by the IPCC (Beck, 2011; Beck & Mahony, 2018; Hulme et al., 2010; Mahony, 2022; O & Oppenheimer, 2024), knowledge politics within the IPCC (de Pryck & Gaveau, 2023; H. Hughes, 2024a; Kouw & Petersen, 2018; Livingston & Rummukainen, 2023; O et al., 2024; van Beek et al., 2022), the (lack of) inclusion of Indigenous Knowledge within the IPCC (Ford et al., 2012, 2016; Van Bavel et al., 2022) as well as the creation of 'global knowledge' through the IPCC (Fogel, 2005; H. Hughes, 2024b, 2024c; Hulme, 2010).

Building upon and situating ourselves within this scholarship, this paper aims to contribute to the understanding of the IPCC by examining its position within the tension field between Eurocentric modernity and emerging efforts to unlearn it. Taking post-colonial scholarship as its starting point (Lumsden, 2021; Malm, 2016; Moore, 2016; Newell et al., 2013; Santos, 2020), this paper intends to analyse

the extent to which the IPCC is shaped by the procedural logic of Eurocentric modernity and to what degree there are tendencies towards unlearning these modernist characteristics in favour of more pluralistic, co-productive approaches. This analytical lens is crucial for two interconnected reasons. First, understanding the IPCC within its modern context helps reveal the historical path dependencies that have shaped this institution. Second, identifying these modernist characteristics is a prerequisite for the process of unlearning – a concept central to post-colonial scholarship. In this scholarship, unlearning is being understood as the critique and moving beyond the modern imaginary (Rösch, 2017). In the context of the IPCC, we understand unlearning as the institutional and procedural transformation through which the IPCC critically examines and moves beyond its embedded modern imaginary.

We employ an inductive-deductive approach through a qualitative methodology based on semi-structured interviews with 26 IPCC authors and 20 policymakers at the international climate conferences of the United Nations Framework Convention on Climate Change (UNFCCC). This dual perspective combines the internal insights of IPCC authors with the external perspective of policymakers, representing the panel's primary audience tasked with translating scientific assessments into concrete climate action. The policymakers' perspective used in this study is crucial as their views can identify potential disconnects between the IPCC's knowledge production processes and the diverse needs of climate policy. This more holistic understanding of the IPCC is necessary for enabling the institution's unlearning-process of its modern roots.

By iteratively analysing the interviews through the IPCC and modernity literature and emerging patterns in the data, we contribute to existing scholarship by empirically examining how the tension between modernist foundations and efforts to transcend them manifests within the organisation. This approach allows us to not only identify the extent of modernist characteristics within the IPCC but also to identify emerging practices and opportunities for institutional unlearning towards more inclusive and pluralistic approaches to climate knowledge production.

We hope that with this paper we contribute to the literature analysing different futures of the IPCC (Asayama et al., 2023; S. Beck et al., 2014; Miller, 2022). With this, we aim to contribute to pathways towards climate resilience, co-created through transdisciplinary processes that transcend colonial hierarchies and foster epistemological and ontological justice (Mignolo, 2011; Mignolo & Walsh, 2018). Rather than relying solely on modernist scientific knowledge and a power-driven political system, this research focuses on 'unlearning modernity' and advocates for pluralistic ways to integrate diverse cosmovisions, knowledges, and ontologies (Arias-Maldonado, 2007; Cadena & Blaser, 2018; Escobar, 2018). Arguing for an IPCC grounded in relational worldviews that re-situate humans as part of, rather than separate from the ecological systems we depend on (Todd, 2016), this paper contributes to the reflexive turn in environmental expertise (S. Beck et al., 2014; Borie et al., 2020; H. Hughes, 2015; Vadrot et al., 2022).

Situated within this reflexive IPCC literature, our paper emerges from our critical reflections and ongoing process of unlearning modernist epistemologies within Western academia. We have grappled extensively with interrogating the hierarchies of (scientific) knowledge. While we acknowledge this is a lifelong learning

journey, we are acutely aware that as WEIRD (Western, Educated, Industrialised, Rich, and Democratic) scholars situated within the German university system, there are inherent tensions and potential hypocrisies in attempting to dismantle these very power structures from within. By publishing work that aims to diversify knowledge in high-cost academic journals that largely reinforce elite, Eurocentric epistemologies and are beneficial for our career advancement, we find ourselves caught in the contradictions of what Mignolo (2011, p. 9) calls the 'colonial matrices of power'. Yet, it is precisely our privileged positionality, which gives us a feeling of responsibility to engage in constant critical self-reflection and commit to an interminable process of unlearning the logic of modernity and actively reflecting upon our privileges. This undertaking demands epistemological humility and openness to value pluriversal ways of knowing, being and relating.

It is important to acknowledge that writing about unlearning modernity, while embedded within modern institutions and thought patterns, presents significant challenges. Our methodology, language and conceptual frameworks are deeply shaped by modernist thinking, often leading us to reproduce the very structures we aim to critique. With regards to language, this has become particularly evident with the binary categorisation of 'Global South' and 'Global North' and the conceptualisation of Indigenous Knowledge. As an alternative to the first terms, we employ the concepts of 'Majority World' and 'Minority World', coined by Alam (2008), to emphasise that the regions often referred to as the 'Global South' contain the majority of the world's population and land mass. Instead of understanding Indigenous Knowledge as a homogenous and static, circumscribed body of information waiting to be recovered, we understand it as various dynamic knowledge systems that have been historically marginalised by Western-centric modernity (Ndlovu, 2014; Van Bavel et al., 2022).

Methodology-wise, we acknowledge that by taking an interview-based approach this research somehow falls back into the linear model itself. Instead of co-creating the knowledge together with relevant stakeholders, by writing interviewing relevant stakeholders in a rather one-directional manner, we are taking the role of researchers aiming to produce relevant knowledge as knowledge base for contributing to the transformation of the IPCC. These examples show the pervasiveness of modernist thought patterns, and we hence acknowledge that the process of unlearning is ongoing and often imperfect and only presents a starting point.

This paper continues as follows: Section Two develops our conceptual framework on modernity, the IPCC and ways of unlearning modernist imaginaries. Section Three introduces our methods, followed by the presentation of results in Section Four. These findings are discussed in Section Five, with Section Six offering concluding remarks and policy recommendations.

5.2 The IPCC, Modernity and Ways of Unlearning

This section follows an inductive-deductive approach, mirroring our empirical data in light of the IPCC and modernity literature. With this, we aim to create a conceptual starting point for the empirical analysis of this

paper. We continue by providing characteristics of modernity, how the IPCC relates to these as well as the IPCC's intentions of unlearning such patterns.

A Characterisation of Modernity

Eurocentric modernity is deeply intertwined with ideals of 'progress,' often defined as the transition from traditional to industrialised or modern societies (Huntington, 1971; Rostow, 1990; Weber, 2001). This concept of progress, driven by industrialisation and technological advancement, is frequently cited as a foundational cause of anthropogenic climate change due to its role towards carbon-intensive development (Andal, 2022; Yalkı, 2023). However, modernisation is not solely a process of economic development; it is also linked to several other historical dynamics that shaped societal structures and continue to influence contemporary climate governance developed in this subsection. First, European colonialism provided the material and ideological basis for modernisation (Arora & Stirling, 2023; Bhambra, 2007; Brunner, 2021). Second, modernisation elevated the role of science as an authoritative source of knowledge and a driver of technological progress (Gaukroger, 2006; Nandy, 1989; Whitehead, 1925). Third, modernisation introduced increasing functional differentiation within societies, establishing distinct spheres such as science, politics, and economics, each governed by its logic and values (Jung, 2017; Schimank, 2013; Ziemann, 2007).

First, what was considered modern progress in Europe is related to European colonialism (Brunner, 2021). The extracting of resources from the colonised world and the solidification of social categories along ethnic and gender lines reinforced unequal power dynamics within societies and across nations and world regions, building the base for the accumulation of wealth in Europe and following global inequalities (Kastner et al., 2019; Quijano, 2007; WGBU, 2023). Next to shaping today's interstate power dynamics, colonialism contributed to substantially shaping societies around the globe, and their functional systems including their knowledge systems.

Second, scientific expertise became a legitimating force and authoritative voice in the project of European modernity's colonial, techno-scientific progress (Nandy, 1989; Trueman, 1949; Whitehead, 1925)[66]. Science's important position in Europe's increasingly secular society developed during the period of the Enlightenment and its ideal of rationality with increasing trust in (Western) science to unveil 'objective truths' about the world (Chatterjee, 1998; Latour, 1993). This positioned science as an autonomous realm capable of producing universal, value-free knowledge superior to other forms of knowledge given its claimed detachment from societal contexts (Chatterjee, 1998; Harding, 2008).

Third and strongly related to science's claimed detachment from social contexts is the increasing functional differentiation of European and European-colonised societies. Functionally differentiated into semi-autonomous subsystems like science, politics, law, and economics, each operating according to its internal

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[66] Examplary for the high value of science for modernity is the inauguration speech of American president Trueman. In point four of this speech he said:" we must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas" (Trueman, 1949, point 4).

logic, specialised codes and programmes, different subsystems became increasingly detached from each other (Easton, 1965; Luhmann, 2012; Parsons, 1970). According to this system's theoretical approach, the political system is governed primarily by political power instead of by 'objective scientific knowledge' (Baraldi et al., 2021; Fuhse, 2005), and hence there is no substantive interaction between the political system and the scientific system taking place more than a one-directional transfer of scientific knowledge to policymakers. In this one-directional interaction, knowledge is taken as the factual base of their value-based decisions (Price, 1981; Weingart, 1999). It is for this reason that since the nineteenth century, scientific assessments 'reviewing the state of expert knowledge about a specific question or problem, judging the quality of the available evidence, and offering findings relevant to the solution of the problem' were undertaken by scientists for policymakers (Oppenheimer et al., 2019, p.3).

The IPCC And Modernity

The IPCC was founded with the mandate to conduct an international scientific assessment concerning the available scientific knowledge on climate change in 1988. By bringing together scientists from all over the world out of their national science systems, it can be said that the panel made a first step towards 'unlearning modern nation states' in a globalised world. However, being a child of its time, the institutional design of the IPCC reflects certain core modern characteristics as well as the strong influence of the Minority World in shaping the panel (Agrawala, 1998a, 1998b; Schneider, 1991; Skodvin, 2000, 2022). Reflecting the global postcolonial power dynamics of the time, it is notable that especially at the beginning a majority of the IPCC authors were from the Minority World as well as the IPCC's Technical Support Units (TSUs) were only located within institutions in the Minority World (Agrawala, 1998b; H. Hughes, 2024a, p. 60; Standring, 2022; Standring & Lidskog, 2021).

Established as an authoritative body of knowledge and expertise on the subject of climate change, the IPCC's cultural foundations elevate scientific and technical modes of expertise over other forms of knowledge (Ford et al., 2012; H. Hughes, 2024a). Lahn & Sundqvist (2017) and van Beek et al. (2022), for instance, highlight that especially quantitative knowledge, often in the form of computer models, is the main epistemic approach represented within the IPCC. Various authors have studied the IPCC to show how this ideal of 'objective science' is enshrined within the institution (de Pryck, 2023; Lahn, 2018; Lahn & Sundqvist, 2017; Mahony, 2022).

Thirdly, this ideal of 'objective science' forming the base of useful knowledge for policymakers is reflected within the institutional design of the IPCC as an assessment-producing institution (S. Beck, 2011; Havstad & Brown, 2017; Hulme et al., 2010). There are certain moments in which scientists and government representatives are brought into interaction with each other, most notably during the complex negotiation of the Summary for Policymakers (SPM) where science is said to hold the pen. While scientists draft the initial text, every line in this 15-50 page summary of the up to 4000-page reports needs to be approved by each government, hence the idea of joint co-production usually does not hold (de Pryck, 2022; H. Hughes & Vadrot, 2023). It is for this reason that the IPCC scholarship highlights that with the assessment reports

being at the core of the IPCC's activity, the IPCC is built upon the linear model of science policy interactions (S. Beck, 2011; Havstad & Brown, 2017; Hulme et al., 2010).

Unlearning Modernity

Questioning the idea of modernity being related to progress, post-colonial scholarship has highlighted the negative consequences of modernity for colonised societies, women and other vulnerable groups (Arora & Stirling, 2023; de Sousa Santos, 2018; Mignolo, 2011). Acknowledging that conceptions of modernity, however, have substantially shaped societies around the world, including their knowledge and political systems, the concept of unlearning is central to post-colonial scholarship (de Sousa Santos, 2018; Escobar & Frye, 2020; Heimisch, 2020). Unlike simple forgetting, unlearning is an active process of critical examination and intentional abandonment of previously accepted truths, habits, and mental models (Durst et al., 2020; Visser, 2017). In the context of modernity, unlearning involves challenging the epistemic and ontological foundations of modernity (Kim, 2024; Quijano & Ennis, 2000). Epistemically, unlearning includes questioning the universalisation and hegemony of Western knowledge and experience, often in the form of scientific 'rational' knowledge, as the sole form of credible knowledge. Ontologically it includes dismantling anthropocentric worldviews and views of development and questioning the hegemony of the West in modern institutions (de Sousa Santos, 2018; Mignolo, 2011).

Concerning unlearning modernity within the IPCC, we understand it as the institutional and procedural transformation through which the IPCC critically examines and moves beyond its embedded modern imaginary (Rösch, 2017). Three tendencies of unlearning modernity within the IPCC have been identified: First, the IPCC's intentions to overcome hegemonic power structures within its institution, second its efforts to enhance the plurality of lived experiences, values, and knowledge systems not captured by science and third ways of moving from the linear model of science policy interactions towards more co-productive approaches.

Concerning the first point of overcoming hegemonic power structures within the modern science system in general and the IPCC, awareness of the importance of representation and diversity within science is increasing (Okamoto, 2013; Standring & Lidskog, 2021). Because scientific knowledge production remains dominated by Western, educated, industrialised, and affluent scholars, calls for science to be produced by scholars from the Majority World, women, and other marginalised groups are increasingly heard within the science system (Guru, 2002; Harding, 2008c; Partelow et al., 2020). Next to the increased awareness for a diverse scholarship, there are increasing calls for including interdisciplinary and qualitative insights from the social sciences and humanities instead of narrowly focusing on quantitative approaches from fields like economics and natural sciences (Hodgson, 2001; Schipper et al., 2021). In the IPCC, this is mirrored by increasing levels of participation of scholars from the Majority World, women and early career researchers as well as social scientists within the institution (Gustafsson, 2022; Petersen, 2022; Standring, 2022). Rising levels of diverse participation, however, do not equate to substantive inclusion of IPCC authors the IPCC authors Caretta & Maharaj (2024) reflect on their experience in the Sixth Assessment Report.

Secondly, there are calls to go beyond the narrow confines of modern Western science and value the pluriverse of knowledges including unpublished knowledge (Escobar, 2018; Hornidge et al., 2023; Kaul et al., 2022). This involves actively engaging with and uplifting Indigenous and Local knowledge systems that have been systematically marginalised by the colonial enterprise of modernity (Ainsworth et al., 2020; Khupe, 2020; Semali & Kincheloe, 2002). While there is an increasing mention of the importance of Indigenous Knowledge within the latest assessment reports of the IPCC, substantive inclusion of this body of knowledge is missing (Ford et al., 2012, 2016). Widening the aperture also means drawing insights from grey literature, civil society reports, and other sources typically excluded from formal scientific publishing channels (Cornell et al., 2013; Hornidge et al., 2016; Hornidge & Scholtes, 2011; Paez, 2017). While most of the IPCC consists of peer-reviewed literature, some selected non-peer-reviewed – so-called 'grey' – literature has been included within the IPCC (Ford et al., 2016; Van Bavel et al., 2022).

A third key avenue for unlearning the linear model centres on fostering sustained co-production and participatory processes that transcend the modern divide between scientific knowledge production and policymaking. Rather than insulating science as a segregated realm of truth-speaking, an emerging transdisciplinary scholarship calls for iterative collaboration where representatives of diverse knowledges and the public are proactively involved in all stages - from initially framing issues to gathering and synthesising evidence, to formulating solutions and implementation (R. Chambers & Conway, 1992; Jasanoff, 2004; Miller & Wyborn, 2020; Turnhout et al., 2019; Wyborn et al., 2019). Built to bring together science and policy, the IPCC's joint approval of the summary for policymakers is often considered the institution's key- co-productive element. While in some cases this joint approval between scientists and policymakers creates policy relevance, it is shown how it sometimes contributes to making the IPCC policy irrelevant instead of policy-relevant (de Pryck, 2022; Lahn & Sundqvist, 2017). It is for this reason that relative to other institutions bringing together science and policy, the IPCC scholarship criticised the linear tendencies within the IPCC, calling for increasing co-production within the IPCC (S. Beck, 2011; Koetz, 2011).

5.3 Methods

This research employs an inductive-deductive approach through a qualitative methodology based on semi-structured interviews with 26 IPCC authors and 20 policymakers at the international climate conferences of the United Nations Framework Convention on Climate Change (UNFCCC). Interviews were primarily conducted during three international climate negotiations of the UNFCCC, namely the 26th and 27th Conference of the Parties in 2021 and 2022 (COP26 and COP27) and the 56th sessions of the Subsidiary Bodies (SB56). Additionally, four interviews were conducted online. Because during COP26 and SB56, the

IPCC presented its 6th Assessment Report, there were especially many IPCC authors present as well as available for interviews on-site[67].

A total of 46 interviews were conducted, with a cumulative duration of 1426 minutes (see Appendix 1[68]). The interviews ranged from 15 minutes to 1.5 hours, with an average duration of approximately 45 minutes. Efforts were made to ensure a balanced representation of perspectives by maintaining regional and gender diversity among the interviewees (Figure 12). The selection of interviewees aimed to capture the viewpoints of both IPCC scientists from different Working Groups and UNFCCC policymakers from various negotiation items[69].

Taking the views of UNFCCC policymakers as an example of how policymakers view the IPCC, it needs to be mentioned that while the IPCC aims to provide policymakers at all levels with policy-relevant information (IPCC, 2021), the links between the IPCC and the UNFCCC are as evident as they are particular (Fogel, 2005; Lahn, 2018; Lidskog & Sundqvist, 2022a). For instance, next to presenting its reports at the UNFCCC COPs, content-wise the IPCC and the UNFCCC are closely interlinked, prominently seen in the IPCC's Special Report on Global Warming of 1.5 °C and the Paris Agreement's 1.5 °C goal (Livingston & Rummukainen, 2023). Further, the COP has 'repeatedly expressed its appreciation for the IPCC's work' and called its bodies 'to seek its advice' (UNFCCC, 2024).
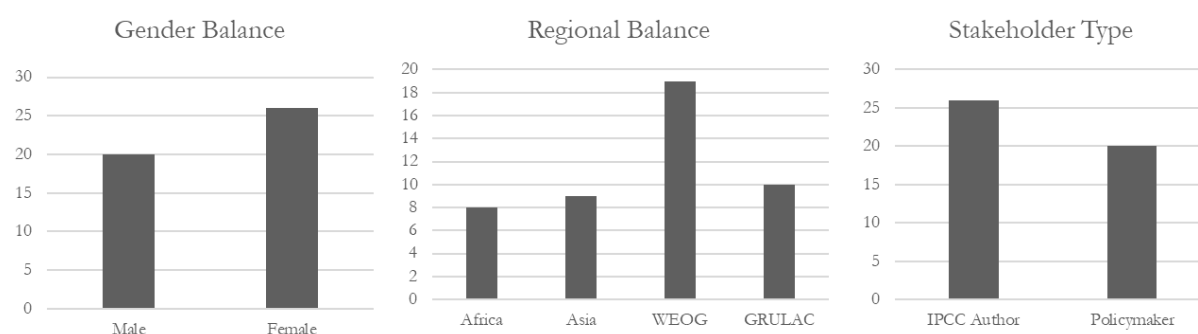
Figure 12: Gender- and regional balance and stakeholder types of interviewees[70]

After interviewees gave their consent to participate in the study, interviews focused on the role of the IPCC for policymaking, criteria for legitimate knowledge-policy interactions within the IPCC, and enablers and barriers to enhancing the legitimacy of the IPCC (see Appendix 2). It did not explicitly ask about specific

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[67] WGI was presented during COP26, WGII and WGIII presented during SB56.

[68] In Appendix 1, Interview IDs are not continuous as interviews were conducted together with research on complexity of collaboration between Rio Convention SPIs and interviews with IPBES and UNCCD SPI were deleted from the Appendix.

[69] While policymakers interviewed were working on a range of negotiation items, nine out of twenty policymakers were especially concerned with agenda items related to science and policy such as Research and Systematic Observations (RSO), the Structured Expert Dialogue (SED) or the Global Stocktake (GST), given that we conducted participant observation in these negotiation rooms for a different research project – possible implications are discussed in Section Five.

[70] Regional grouping is based on the United Nations five regional groups with GRULAC standing for 'Group of Latin America and the Caribbean' and WEOG stands for 'Western European and Others Group'.

characteristics related to modernity or unlearning but questions were framed in a more general manner asking for instance about the role of the IPCC reports for policymaking, to what extent they trust the IPCC or to what extent participants believed that the IPCC fairly represents the current state of knowledge on climate change. While the interview guide provided a structured framework, it also allowed for flexibility, enabling participants to highlight and discuss themes or perspectives that were not explicitly covered in the predetermined questions.

The interview recordings were transcribed verbatim, and the transcripts were imported into MAXQDA 2022 Software for qualitative data analysis. An inductive-deductive approach was employed for coding the data as well as to develop the conceptual part presented in Section Two (Boyatzis, 1998; Houben, 2017; Mielke & Wilde, 2017). The inductive-deductive approach combined theory-driven a priori codes derived from the existing literature with emergent codes that were identified through a constant comparison technique during the analysis of the interview and document data (Tesch, 2013). This allowed us to identify emerging themes and continuously refine our coding structure with the final coding structure encompassing aspects of the IPCC being related to modernity and unlearning it.

The data analysis process aimed to uncover insights into how the logics of modernity shape the IPCC, as well as potential processes of unlearning these logics. To further refine our understanding, the coded data was then analysed through stratification and cross-tabulation techniques, considering mainly stakeholder types (IPCC authors, UNFCCC policymakers) and Working Groups of the IPCC authors. Further the categorical variables gender and region collected during the interview process were also cross-tabulated. The conceptual results of this inductive-deductive approach are presented above in Section Two, and the empirical findings from this analysis are presented and discussed in the subsequent sections of the paper[71].

5.4 Results

The empirical findings from our interviews with IPCC scientists and UNFCCC policymakers show how the IPCC finds itself within the tension field of being shaped by the legacies of modernity and unlearning it. On one hand, we find that the IPCC remains profoundly structured by modern ideals of functional differentiation, linear knowledge transfer, and universalised scientific expertise guiding policymaking. On the other hand, our results show a nascent awareness that suggests an 'unlearning' of these modernist characteristics is tentatively underway. Based on the inside view of IPCC authors and the outside view of one of the IPCC's main audiences, the UNFCCC policymakers, the following subsections explore these contrasting patterns in detail, highlighting both the enduring power of modernity's legacy as well as the cracks and fissures opening up alternative trajectories within the IPCC. Our analysis showed as well that the

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[71] During the preparation of this work, the authors used the generative AI-software „claude.ai", „Grammarly" and „ChatGPT" to improve language and readability in editing parts of the text. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

number of coded segments across the different codes was proportional to the number of interview partners across regions and genders. This was not the case for stakeholder types and Working Groups with results being presented below.

Characterised by Modernity? – The IPCC as Linear Mediator between Policy and Science

Equating the IPCC with Science, Knowledge and Truth

The interviews with IPCC scientists and UNFCCC policymakers highlight the pivotal role of the IPCC as the primary information and knowledge base for policymaking within climate governance at the international level. For both IPCC scientists and UNFCCC policymakers interviewed, the IPCC's assessment reports are widely regarded as a knowledge foundation for policymaking[72], as evidenced by this quote from an interviewee: „I think it is kind of a foundation. I think all this work started with science. I guess the basis of our negotiations, at least from a scientific point of view, it is based on science" (Interview 14, UNFCCC policymaker).

Notably, the IPCC is often equated with science, knowledge, and even truth itself. Interviewees consistently expressed the view that the IPCC's assessments represent the 'best available science' or even science overall[73]. One interviewee stated, „You cannot separate them. The IPCC is all based on the science" (Interview 15, UNFCCC policymaker). Some policymakers went so far as to equate the IPCC with truth itself, as exemplified by this quote: „I must say that I trust them completely. And not only because they speak the truth, but they also include what they do not know" (Interview 13, UNFCCC policymaker).

These perspectives reflect a hierarchical view of knowledge, where science is perceived as the only valid form of knowledge. The IPCC's scientific assessments are granted a privileged status, serving as the authoritative foundation upon which the political negotiations within the UNFCCC are based.

The IPCC as Neutral and Non-policy Descriptive Base for Policymaking

The authority of the IPCC as the primary scientific knowledge base for international climate policymaking is largely based on the perception of the IPCC as an objective and neutral source of scientific information[74]. This perception is shared by policymakers and IPCC scientists, as evidenced by statements such as „the IPCC is designed to provide an objective basis for providing these assessment reports" (Interview 70, IPCC author), or „we have to remember that IPCC reports have to be relevant, but they have to be neutral" (Interview 20, IPCC author), and „IPCC cannot go so as not to compromise its scientific independence and scientific neutrality" (Interview 63, IPCC author). The IPCC's perceived objectivity and neutrality are further reinforced by its quantification of uncertainty through a „calibrated uncertainty language" (Interview 20, IPCC author). This was further highlighted by one policymaker:

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[72] Interviews 4,7,13 (IPCC authors); Interviews 6,8,9,11,14,15,16,17,21,38,42,43,45,64,67 (UNFCCC policymakers)
[73] Interviews 2,3,12,14,15 (UNFCCC policymakers)
[74] Interviews 20,21 (IPCC authors); Interviews 8,63,67,70,71 (UNFCCC policymakers)

> *„ The IPCC has also developed or invented the language that helps you to quantify and to formalise and to make the assessment as objective as possible so that wherever you see there is high confidence on one of the findings or there's medium confidence in some of the findings, you can know exactly what that means through that calibrated uncertainty language" (Interview 43, UNFCCC policymaker).*

The IPCC's role is mainly perceived as providing policymakers with the necessary information and scientific certainty to guide their decision-making[75]. As one interviewee stated, „I think policymakers need information and they need to reduce their uncertainty about what is going to happen. I guess this is our role, to try to give enough data and to give the best information, so that the higher certainty we can reduce errors" (Interview 62, IPCC author). This 'truth to power' tendency is reflected as well in the IPCC dissemination events organised during the UNFCCC COPs, including the mandated events and IPCC events at the Science Pavilion and the UNFCCC cover decisions frequently refer to the IPCC as an authority of knowledge. This follows the logic of the linear model of policymakers listening to scientists about the climate crisis.

The IPCC's mandate is to provide policy-relevant but not policy-prescriptive assessments (IPCC, 2021). This principle is deeply ingrained in the IPCC's identity and repeatedly emphasised by interview participants from within and outside of the IPCC[76]. As one IPCC author stated, „The mandate of the IPCC is to assess the literature neutrally and provide an assessment of that in the most accessible way that's policy-relevant, that's not policy prescriptive and all of that. That's the mandate and that's what is drilled into us as IPCC authors" (Interview 67, IPCC author). Another interviewee echoed this sentiment, saying, „I mean we are extremely careful in trying to balance the line that we are not telling policymakers what to do, but rather present pathways to adaptation options" (Interview 42, IPCC author). While maintaining the distinction between 'is' and 'ought', facts and values, can be challenging in practice, the dominant perception of the IPCC we found is that it is perceived to be based on the principles of objectivity and neutrality, providing the scientific information base for policymaking.

This distinction between descriptive and prescriptive, facts and values is sometimes challenging for policymakers hoping to receive information on what normatively should be done to address climate change: „So I think the IPCC is a very comprehensive report because it gives us at least a hint of where we think we shall go when we depend on the different scenarios anyway." (Interview 38, UNFCCC policymaker).

Systems Logic Shining Through the Veil of the Linear Model

In the Summary for Policymakers (SPM), introduced in Section 2.3 as a product of complex negotiations between IPCC authors and government representatives, this negotiation aspect of the SPM was generally known among our interview participants. Among policymakers as well as among some IPCC authors interviewed, there was the perception that in the SPM production process 'science holds the pen', and the

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[75] Interviews 4,7,20,39 (IPCC authors); Interviews 14,38,43,26,64,67,70,72 (UNFCCC policymakers)
[76] Interviews 37,42 (IPCC authors); Interviews 43,63,64,65 (UNFCCC policymakers)

message is not changed by policymakers[77]: „The SPM again, at the end of the day, the authors hold the pen. If you think that the suggestions suggested by the countries are not in line with the science, we have the ability to say no" (Interview 4, IPCC Author). Another participant noted that „wording is changed because it's more neutral or because otherwise, it would be prescriptive, that is part of the process" (Interview 20, IPCC Author), suggesting that changes are made to maintain the scientific integrity and policy neutrality of the SPM.

However, some IPCC authors (and none of the UNFCCC policymakers) also noted the influence of power logic of the political system, where governments seek to water down the report's findings to suit their interests as the following two quotes represent:

> *„It's supposed to be about the science. So why are they taking away, changing the messages, watering down the language? They're meddling, meddling with the science, meddling with the statements […]. That is their mission".* *(Interview 64, IPCC author).*

> *„And I mean, you get your classic petro states and others really trying to water down as much text in the summary for policymakers as possible, particularly around responsibility for historical emissions" (Interview 68, IPCC author).*

Contrary to claims of being the knowledge base for policymaking, some policymakers interviewed highlighted the selective use of the contents of the IPCC to policymakers' advantage, reflecting the modern systems logic of powerful political systems[78]. As one policymaker stated, „For some parties it's more a role of window dressing. For others it's a key role just to put pressure" (Interview 10, UNFCCC policymaker). Another policymaker acknowledged that „we should never forget that at the end of the day, the science, that part of the evidence is just one part and it's not the whole picture of how countries make decisions. And this is true for the UNFCCC process, but this is also true back home for each of the countries" (Interview 20, IPCC author[79]). One scientist summarised this as follows: „They listen to the science when it's their agenda" (Interview 46, IPCC author).

These contrasting perspectives highlight the tension between the ideals of modernity, represented by the notion of „pure and universal science," and the realities of the political system's logic, where power dynamics and interests come into play. While the IPCC is perceived as embodying the principles of objective and neutral science, especially during the government approval of the IPCC's summary for policymakers, the power logic of the political system shines through when scientific messages may be subject to negotiation and potential watering down to align with the interests of governments.

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[77] Interviews 4,8 (IPCC authors); Interviews 2,3,63,67,71 (UNFCCC policymakers)

[78] Interviews 6,14,15,38 (UNFCCC policymakers)

[79] This IPCC Author hold as well a political role.

Tendencies of Unlearning Modernity within the IPCC

While the IPCC and how it is used by policymakers is shaped by modernity, our findings mirror as well the tendencies and perceived needs for unlearning these modernist characteristics. Notably, the recognition of the inadequacy of the linear model and the need to unlearn the systems logic of modernity was more prominently voiced by the IPCC scientists interviewed, than by policymakers interviewed. In the following subsections, we explore these emerging tendencies towards unlearning modernity's logic, structured around the three themes of Section Two: the call for more diversity within the IPCC and science system, the recognition that knowledge is more than scientific knowledge, and the importance of co-production in knowledge-policy interactions.

Pluralising Scientific Perspectives

The interviews revealed a growing awareness and call for a more diverse and inclusive conception of science within the IPCC process for increasing the credibility and relevance of the IPCC. One area of concern was the language barrier for both the interviewed scientists and policymakers, with non-native English speakers facing difficulties in comprehending the reports[80]. Although there was an awareness that the IPCC and science, in general, are English-heavy, efforts to incorporate literature from other languages remained limited, as one participant acknowledged[81]: „It is still English heavy but, we had authors who could read Spanish, who could read Chinese and Russian. So we ask them to use all of that literature, but at the end of the day, we all of us ended up relying a lot more on English literature"(Interview 71, IPCC author).

Concerns were also raised about the domination of certain disciplines, particularly those focused on technological solutions, while other themes and disciplines, such as history, spirituality, and anthropology, were mentioned to be underrepresented[82]. Further the relevance of ethics for the importance of clarifying the underlying normative assumptions of scenarios for increasing the relevance within the negotiations was highlighted. There were also acknowledgements of improvements in the inclusion of social sciences and humanities[83].

In addition to disciplinary imbalances, research participants mentioned various topics as being underrepresented in the IPCC process, such as finance, adaptation, intersectionality, equity, and gender[84]. While efforts were being made to address gender representation through the establishment of a gender action group and improvements were perceived in covering all regions, there was a recognised need for greater inclusivity of diverse perspectives[85]. Improvements, however, were noted in terms of gender

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[80] Interviews 16,19,41,45 (UNFCCC policymakers)
Interviews 16 and 19 were partially conducted in French or Spanish as interviewees felt more comfortable in this as these interviewees Interviews 19,41,45 (UNFCCC policymakers)

[81] Interview 37 (IPCC author); Interviews 9,19,41,45,63,68,71 (UNFCCC policymakers)

[82] Interview 21 (IPCC author); Interviews 16,46,65,67 (UNFCCC policymakers)

[83] Interview 46 (IPCC author)

[84] Interviews 7, 21,42,46,47,67, 68 (IPCC Authors) and Interviews 6,14,61 (UNFCCC policymakers)

[85] Interview 47 (IPCC author); Interviews 6,8 (UNFCCC policymakers)

representation and the inclusion of authors from the Majority World [86], as captured in the following quote of a (female) IPCC author from Asia:

> *„If you go back to AR1, AR2, it was a very small group of mostly people from the global North that were writing all those reports. So since then, we have seen a huge amount of diversity. AR6 was particularly diverse, and another thing that has happened, is not only has the authorship base become more diverse, but we were the only woman-led chapter in the entire IPCC, right? So this is seen as like we are still the only one. So you can imagine, our chapter was diverse. We had like an equal number of people from the global South global North"* *(Interview 71, IPCC author).*

Notably, there was a widespread awareness of missing perspectives within the IPCC process, particularly those of young people, gender, and the Majority World [87]. This awareness extended to (male) IPCC scientists from the Minority World, as one participant acknowledged: „The IPCC does work on this, but it really has to come to practice what it can preach towards. So I ought not to be invited back. They ought to get someone else in to do it because there are lots of good people out there" (Interview 21, IPCC author). Another IPCC author had reflections on the importance of reflexivity:

> *„There's an intergenerational difference in who is trained in active listening and who isn't. For example, younger people are more aware that if you're a white male in the circle, you shouldn't be the one dominating the conversation. That sort of reflectivity is definitely present in the under-forties, but less so with older participants in the process. This speaks to questions of how inclusive the process is and how inclusive the knowledge creation is. If you're a woman of colour from a low-income group, with insufficient internet bandwidth to have your video on during a Zoom meeting - just a voice - you're much less inclined to challenge what some Global North male at Potsdam has just said, even if you feel strongly that their statement was inappropriate. So yes, there are always challenges"* *(Interview 68, IPCC author)*

Policymakers interviewed mentioned that diversity and inclusion is important for the credibility of the IPCC reports as well as the relevance: „If we can have more authors from the developing countries, more from Africa, it would be easier to capture our realities better" (Interview 16, UNFCCC policymaker). However, structural problems within the scientific enterprise itself were also acknowledged, such as the IPCC's reliance on the current state of funding for science, which is highly unequally distributed, as one IPCC author noted:

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[86] Interviews 7 (IPCC author); Interviews 16,69,71 (UNFCCC policymakers)

[87] Interviews 4,7 (IPCC authors mentioning young people); Interviews 11,19,68 (UNFCCC policymakers mentioning young people); Interviews 4,7 (IPCC authors mentioning gender equality); Interviews 16,68,69 (UNFCCC policymakers mentioning gender equality); Interviews 4,7,20,21 (IPCC authors mentioning representation from Majority World); Interviews 6,16,63,67,69,70 (UNFCCC policymakers mentioning representation from Majority World)

„For example, from 1990 till 2018 out of $1.3 trillion with research finance spent on climate change topics, only 3% of that has focused on Africa. And less than half a per cent of that has been spent on African research priorities in Africa like the overwhelming amount of research has focused on areas of the world that are less at risk from climate change" (Interview 68, IPCC author).

Additionally, the sheer volume of literature being produced posed challenges in comprehensively assessing all available scientific knowledge[88].

Including More than Science

There was widespread awareness among both IPCC scientists and UNFCCC policymakers that scientific knowledge alone is not sufficient to address the complexities of climate change. This awareness was especially prominent among authors from WGII interviewed for this study, likely to be linked to the Working Group's focus on impacts and adaptation solutions to climate change and the importance of non-technical and local pathways for this. Recognising the limitations of relying solely on scientific knowledge, efforts were made to incorporate other forms of knowledge, such as Indigenous and Local knowledge, as well as grey literature and practitioner insights.

Regarding Indigenous Knowledge, there was an acknowledgement of the challenges involved in its inclusion within the IPCC, but also increasing efforts to incorporate it[89]. One participant provided an example of how Indigenous Knowledge was included, despite the difficulties encountered in the process:

„We try to include first-person narratives from Indigenous people as a source of knowledge. So, people who were leaders and really well known in terms of contributing and holding wisdom, like knowledge holders on the topic, wrote like a half page to a page section, basically reflecting embodied knowledge that they have. And that is, you can see that actually in the first-order and second-order drafts. But in the peer review process, especially from governments, there was a lot of pushback that it didn't follow the policies and procedures outlined by IPCC and that it wasn't based on literature. And so we had to basically take those statements and we made a call for like a book compendium from Indigenous authors and to publish something in the literature so that we could cite it" (Interview 69, IPCC author).

Policymakers noted that the inclusion of Indigenous and Local Knowledge in the IPCC increases the relevance of UNFCCC negotiations, especially in the context of adaptation. As one policymaker noted, „including Indigenous people's knowledge and traditional knowledge does increase relevance. And especially for adaptation I believe" (Interview 15, UNFCCC policymaker).

Similarly, there was an awareness of the importance of incorporating local knowledge, although capturing local experiences posed challenges due to the vast diversity and scale of such knowledge, as one participant acknowledged[90]: „There's such an amount of local level experiences that you simply cannot capture in a

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[88] Interviews 17, 40, 46, 69, 71 (IPCC authors)
[89] Interviews 40,42 (IPCC authors); Interviews 15,67,69,71 (UNFCCC policymakers)
[90] Interviews 40, 42, 68 (IPCC authors)

report of finite length" (Interview 40, IPCC author). Efforts were also made to include grey literature and practitioner insights to increase the relevance and applicability of the IPCC's assessments[91].

Co-Production within the IPCC

Contrasting to the views on how the interactions between science and policy make the IPCC irrelevant, some interview partners view the IPCC as an example of co-production, where scientists and policymakers are provided a platform to co-create knowledge for addressing the climate crisis. This perception of fruitful co-creation was more prevalent among IPCC scientists than among UNFCCC policymakers interviewed, possibly related to the fact that IPCC scientists have an intimate understanding of the process from within, while the UNFCCC policymakers still predominantly view the IPCC as representing „pure and unified science" [92].

The IPCC process itself was often described as a co-creation process, with several examples illustrating this co-productive nature. As one interviewee stated, „I call it a co-design process. Because we listen to the needs for information indicated by governance at the very beginning" (Interview 7, IPCC author). This constant interaction between scientists and policymakers is evident in various aspects of the IPCC process, such as the nomination of authors by governments and the dual roles of some individuals as both scientists and policymakers[93]. Additionally, scientists and policymakers are brought together during various procedural steps of creating reports, most notably the scoping of the outline, the peer-review comment process, and the creation of the SPM.

The scoping process for special reports, where the outline of the report is co-created by government representatives and authors, provides authors with the mandate to synthesise peer-reviewed science for a specific topic [94]. The peer-review process, in which the IPCC collects thousands of comments from experts and government representatives, is also seen as a co-productive element, albeit with potential epistemic benefits and concerns about the predominance of comments from the Minority World[95].

Regarding the SPM creation, despite some tendencies of governments to „water down" the SPM (as discussed in Section 4.1), many authors described the process as an example of how policy relevance is co-created[96]. One author stated:" I love those sessions [...] because we are making sure that science doesn't just sit on the shelf" (Interview 69, IPCC author). Another participant noted, „They're helping to make the SPM relevant for policy" (Interview 37, IPCC author).

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[91] Interviews 42,46 (IPCC authors); Interviews 62,63,65,67 (UNFCCC policymakers)

[92] Interviews 4,7,9,10,17,18,20,37,39,40,42,46,47,68,69,70,71,72 (IPCC authors); Interviews 18,43 (UNFCCC policymakers)

[93] Interviews 10, 17, 46, 69, 72 (IPCC authors)

[94] Interview 69 (IPCC author)

[95] Interviews 4,7,40,42,69,71 (IPCC authors mentioning review process); Interviews 18,65,68 (UNFCCC policymakers mentioning epistemic benefits); Interviews 40,68,71 (concerned with Minority World dominance)

[96] Interviews 37, 39, 40, 42, 69, 70, 71 (IPCC authors)

With the IPCC aiming to bring together science and policy, it needs to overcome the strict distinction between facts and values and needs to bridge these domains[97]. Contrary to the expectation of universalist science, for normatively laden questions related to equity and historical emissions, there is no single answer, as one interviewee explained:

> „*There are different lenses through which to view the world. If you are more concerned about historical emissions and historical responsibility, whether you're concerned about a top-down approach to equitable sharing of mitigation burden or whether you focus more on options and cost-effectiveness of approaches. So there's a limit to what a science-based report can deliver [...] because there is no single answer*" (Interview 40, IPCC author).

For this reason, there are calls from IPCC scientists to embrace a more political role and produce products that directly inform key questions for policymaking[98]. Given that the role of the IPCC has moved beyond 'overcoming climate scepticism' (Interview 72, IPCC author) and now focuses on mitigation and adaptation solutions, the need for the IPCC to co-produce future reports is frequently mentioned[99]. However, for co-production within the IPCC context to contribute to policy-relevant climate solutions, it is important to acknowledge that the idea of „pure science" needs to be unlearned, as one participant noted:

> „*If you want to retain sort of academic purity, which also comes with an assumption of academic superiority that you know the world better than the people who you're writing the report for, then you might be more troubled*" (Interview 40, IPCC author).

This view of 'academic purity' mentioned here seems to be relatively widespread within and outside the IPCC suggesting a long unlearning path in front of the institution.

5.5 Discussion

Towards Unlearning Eurocentric Modernity?

In our research, we show that the IPCC is profoundly shaped by the procedural characteristics and logic of Eurocentric modernity. The linear model of knowledge transfer, positioning science as an autonomous realm providing objective knowledge to guide policymaking, is evident in how the IPCC's assessments are perceived as the authoritative knowledge foundation for policymaking at the international climate level (S. Beck, 2011; Skodvin, 2000). The boundary between science and policy spheres found in this paper aligns with the systems theory logic of functional differentiation, demarcating these two domains as separate and governed by distinct logics, as seen in the view of the IPCC as a neutral arbiter providing policy-relevant but not prescriptive knowledge as found in the literature (Girod et al., 2009; Hulme et al., 2010; Hulme & Pryck, 2022). Our findings show that especially policymakers hold this belief in the IPCC as the neutral

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[97] Interviews 7,40,47 (IPCC authors); Interviews 2,3,21,64,67,70,72 (UNFCCC policymakers)
[98] Interviews 7,9 (IPCC authors); Interviews 21,64 (UNFCCC policymakers)
[99] Interviews 40,72 (IPCC authors); Interviews 64,67 (UNFCCC policymakers)

knowledge foundation for policymaking while IPCC authors with their inside view often hold a more differentiated view.

However, the findings underscore tendencies towards contesting and 'unlearning' these modernist characteristics within the IPCC. These efforts are aimed at broadening disciplinary and regional diversity, with increasing participation of female scholars, researchers from the Majority World, and social sciences/humanities, mirroring long-standing calls for more inclusive representation (S. Beck, 2011; Ford et al., 2016; Jones, 2013). There is growing recognition of the need to incorporate alternative epistemologies like Indigenous and Local knowledge and grey literature, echoing repeated exhortations for the IPCC to engage with diverse knowledge systems beyond Western science (Ford et al., 2012, 2016; Mustonen et al., 2022).

These findings on the growing recognition of the need to increase diversity and inclusion within the IPCC mirror recent empirical studies revealing a more complex reality of the knowledge policy interaction shaping the IPCC than the linear model of knowledge transfer dominating the perception of the IPCC. As exemplified by the 1.5 degree Special Report and the Paris Agreement's 1.5 degree goal, the IPCC assessment process has frequently served to legitimate targets and concepts that originated within political negotiations (Fogel, 2005; Lahn, 2018, 2021; van Beek et al., 2022). Member governments actively shape knowledge products throughout the assessment pathway, from outline development to final approval (de Pryck, 2022; H. Hughes, 2024c). Thus, while the linear model of science informing policy may persist in discourse and institutional self-understanding, we acknowledge that actual practices demonstrate a more intricate interplay between scientific assessment and political negotiation processes.

Methodological Considerations

The findings suggest some transformations are tentatively materialising within the IPCC, mirroring broader shifts towards co-production, transdisciplinarity and pluralistic knowledge integration, driven by increasing pushes from both within and outside the institution. Following Bourdieu's invitation to reflexivity (1992), it is worth noting that the perspectives shared by interviewees are not neutral or isolated but are deeply embedded within the IPCC knowledge ecosystem with the interviews contributing to the circular, reflexive nature of knowledge production within this system. Interviewees are influenced not only by their own experiences but also by their interactions with IPCC publications, policy debates, and broader academic literature on climate science and governance. This reflexive interdependence underscores a co-productive relationship in which interviewees' knowledge both shapes and is shaped by ongoing scientific and policy discourses.

Further methodologically the following needs mentioning: First, the data collected is, of course, bound to the specific context it was collected in. While we use the case of UNFCCC policymakers as an example of policymakers using the IPCC, the UNFCCC context is certainly very specific, and it would be very interesting to research a similar question with different types of policymakers across different regions and levels of policymaking. Second, it was mentioned in Section Three that nine out of twenty policymakers

were especially concerned with agenda items related to science and policy[100]. Relative to policymakers working on other topics, these policymakers were more knowledgeable about the IPCC and possibly shaped their delegations' views on the IPCC. This could point to the importance of conducting interviews with this group. However, it needs to be acknowledged that the knowledge of these nine UNFCCC policymakers on the IPCC does not represent the level of knowledge of the IPCC across UNFCCC policymakers. Third, conducting interviews on-site had the advantage for us to collect relatively high numbers of interviews due to the direct access to interview partners while, especially towards the end of the conference, interview partners were mentally and physically exhausted – possibly affecting the depth of their answers. It is further to be mentioned that while we conducted more interviews with stakeholders from the Majority World, the number is still not proportional to the number of inhabitants of this part of the world. While this might reflect the current state of the IPCC and is possibly related to our positionality, it is important to acknowledge this concern.

Given its grounding in a Western academic tradition and the inherent biases stemming from our positionality, future scholarship from diverse perspectives is needed to continue interrogating the extent to which 'unlearning' modernity is feasible within the IPCC context. Ultimately, however, any research project aimed at interrogating modernity characteristics within IPCC should remain committed to continual critical self-reflection, epistemological humility, and centring voices from those communities most impacted by climate change and marginalised by Eurocentric knowledge systems.

Risks of Unlearning Eurocentric Modernity

The tendency toward unlearning Eurocentric modernity within the IPCC is not without potential pitfalls and risks. One concern is that opening up scientific assessments to competing knowledge claims and definitions, as part of embracing pluralism, could inadvertently weaken the scientific authority and credibility of these institutions. As Lahsen and Turnhout (2021) note in the context of the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES): „The acceptance of competing knowledge claims and definitions that such pluralism may require is challenging, not only because it is incompatible with IPBES' current approach, but also because of concerns to preserve the assessment's scientific authority" (ibid., p.5). A perceived risk exists that broadening epistemological inclusion beyond scientific knowledge does not allow science to „speak with one voice" through consensus-based assessments, potentially fuelling climate denialists and sceptics who already subject the IPCC's findings to intense scrutiny.

Additionally, there is a risk of overcorrection in the emphasis placed on Indigenous Knowledge systems. While the inclusion of Indigenous Knowledge is crucial for epistemological justice and enriching understanding of climate change and related demands for justice, only a small minority of the world's population identifies as Indigenous (Amnesty, 2024). The vast majority of knowledge is not of a scientific nor Indigenous nature - it resides in diverse local experiences that may not neatly fit the Indigenous/Western

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[100] This is related that we conducted participant observation in these negotiation rooms for another research.

dichotomy (Antweiler, 1998; Briggs, 2005). An overemphasis on Indigenous epistemologies could contribute to overlooking other vital sources of lived expertise and contextual insights.

Furthermore, the move towards co-production and transdisciplinary collaborations between scientists, policymakers, and stakeholders is not immune to the potential reproduction of existing power dynamics and inequalities (Lahsen & Turnhout, 2021; Miller & Wyborn, 2020; Wyborn et al., 2019). Without careful attention to procedural characteristics such as inclusivity, accessibility, and transparency, co-production processes could perpetuate the marginalisation of certain voices and knowledge, reinforcing rather than dismantling Eurocentric hierarchies; substantive inclusion, accessibility and transparency must be actively fostered to prevent the co-optation of these well-intentioned initiatives (N. Wagner et al., 2024). While the unlearning of Eurocentric modernity holds transformative potential, these risks highlight the need for a delicate balance to be struck in this critical endeavour.

Possible to Unlearn Eurocentric Modernity?

Despite the tendencies of unlearning modernity, the question of whether it is truly possible to transform the institutional set-up of the IPCC towards embracing pluriversal knowledge systems needs to be asked. Post-colonial scholars argue that attempts to decolonise and diversify knowledge within Western-dominated institutions will inevitably run up against fundamental epistemological contradictions and entrenched power (S. Chatterjee et al., 2023; Mignolo, 2011). From this perspective, a genuine epistemological plurality may necessitate the creation of entirely new autonomous institutions and knowledge architectures beyond the constraints of Eurocentric modernity. However, other scholars point to the value of sustained efforts to „unsettle" and transform existing institutions from within, as difficult as that may be (Arora & Stirling, 2023; Bennett et al., 2021). The nascent tendencies observed within the IPCC could potentially gather momentum to gradually erode modernist boundaries and create new pluriversal institutional cultures.

5.6 Conclusion and Policy Recommendations

The findings from this study find the IPCC to be torn in a tension field between modernity and unlearning it: On one hand, path-dependencies of Eurocentric modernity shape this institution through the linear model of knowledge transfer, the systems logic of differentiated science and policy spheres, and the privileging of Western scientific expertise as universally valid and apolitical. However, cracks are emerging in this modernist edifice, with growing recognition of the need for more holistic, pluralistic, and co-produced approaches to knowledge and policymaking on climate change, calling explicitly for the inclusion of different knowledges as well as the improvement of participation possibilities of underrepresented groups.

This study contributes to the body of literature on the IPCC by examining the perspectives of IPCC authors and policymakers using the IPCC with a modernity-critical lens, revealing both persistent modernist influences and emerging efforts to transcend these limitations. With this, this paper aligns with broader

discussions on epistemic inequalities and structural challenges in other global science-policy interfaces and efforts transcending these (ISC, 2022; T20, 2018; UNESCO, 2021).

Acknowledging that there is no one-size-fits-all solution (S. Beck et al., 2014), this study advocates for nurturing the nascent tendencies found in the IPCC for unlearning its modern imaginary and proposes three concrete policy recommendations based on suggestions derived from the interviews conducted for this study: First, we recommend broadening substantive and meaningful participation of knowledge holders from the Majority World. While broadening the participation of scholars from the Majority World has been a goal since the IPCC's inception (Agrawala, 1998b; Skodvin, 2022), the literature identifies notable strides in this area by the IPCC. However, structural barriers persist that continue to restrict equitable participation and the meaningful impact of Majority World scientists (Caretta & Maharaj, 2024; H. Hughes, 2024a; Standring, 2022). These barriers include various forms of capital, such as highly unequal access to funding, language limitations, and entrenched academic norms that disadvantage contributions from the Majority World (H. Hughes, 2024a). To address these challenges, it is recommendable for the IPCC and its funding member states to reinforce long-term support mechanisms for scholars from underrepresented regions, for example, by expanding regional training and funding opportunities and developing frameworks to reduce language and resource inequities[101]. Another crucial recommendation is to develop comprehensive reflexivity training programs for Minority World participants, enabling them to better recognise and address power imbalances that can silence vital perspectives from underrepresented groups[102].

In addition to broadening substantive participation, it is essential for the IPCC to establish clear criteria for the inclusion of Indigenous and Local Knowledge. Indigenous communities bring context-specific insights into climate change impacts and adaptation that are often overlooked within conventional scientific frameworks (Ford et al., 2016; Van Bavel et al., 2022). While efforts have been made to incorporate more diverse knowledges, these contributions are often marginalised due to a lack of formal guidelines on what constitutes credible Indigenous Knowledge within the IPCC process. Developing structured criteria for including Indigenous as well as Local Knowledge would not only increase the depth and breadth of the IPCC's findings but also acknowledge the legitimacy of diverse epistemological frameworks[103]. Learning from the experiences of IPBES, which has made significant advances in formalising the inclusion of Indigenous Knowledge, could serve as a starting point to strengthen IPCC practices (Borie & Hulme, 2015; Chiarolla & Savaresi, 2017).

Third, the IPCC should adopt knowledge-policy co-production as a guiding principle, embedding iterative and participatory collaboration between scientists, policymakers, and diverse knowledge holders throughout the assessment process. While existing co-productive practices, such as co-creating report outlines and jointly approving the Summary for Policymakers, establish a possible starting point for collaboration, the IPCC's traditional linear model often restricts open deliberation on normative issues essential for policy (S.

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[101] Interviews 4,7,20,21 (IPCC authors); Interviews 6,16,63,67,69,70 (UNFCCC policymakers)

[102] Interviews 64, 68 (IPCC authors)

[103] Interview 69 (IPCC author)

Beck, 2011; de Pryck, 2022; Koetz, 2011; Lahn & Sundqvist, 2017). Embracing a co-productive approach could encourage stakeholders to address normative and value-laden aspects of climate change policy together rather than attempting an apolitical stance, as several interviewees emphasised the need to move beyond 'neutral and objective science' to address politically charged questions such as equity and historical responsibility[104]. However, to prevent risks of reproducing power asymmetries between these processes, transparency, accessibility as well as reflexivity are needed as procedural safeguards for this collaborative knowledge production within the IPCC (Lahsen & Turnhout, 2021; N. Wagner et al., 2024).

Implementing such recommendations is not without challenges, but a failure to do so risks perpetuating the marginalisation of vital perspectives and undermining the epistemic and political legitimacy of the world's most prominent knowledge institution on climate change. Ultimately, striving to unlearn the modernist underpinnings of the IPCC is not merely an academic exercise – in the era of climate emergency, it is a core concern for climate justice. By situating itself within this wider movement towards more equitable and diverse knowledge systems, the IPCC has the opportunity to lead by example in reimagining how knowledge can inform and co-create effective climate policy.

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[104] Interviews 40 and 72 (IPCC Authors)

CHAPTER 6: CONCLUSION

6. Conclusion

6.1 Summary of Analysis: Legitimate Knowledge Policy Co-Production Enhancing SPIs for Contributing to Just Climate Action

The research presented here explored SPIs and related ways of enhancing them. This section synthesises the key research findings of this dissertation, arguing for 'Legitimate Knowledge Policy Co-Production' (LKPC). LKPC is conceptualised as a way of configuring how knowledge and policy can be brought together within SPIs overcoming the modern imaginary of the linear model as well as the shortcomings of 'standard knowledge policy co-production'. This section continues by characterising LKPC's relation to both the linear model and standard co-production approaches. Then, it is demonstrated how LKPC enhances both the epistemic and participatory quality of SPIs which in turn contribute to more effective and just climate action outcomes (illustrated in Figure 13 and laid out in Table 13).
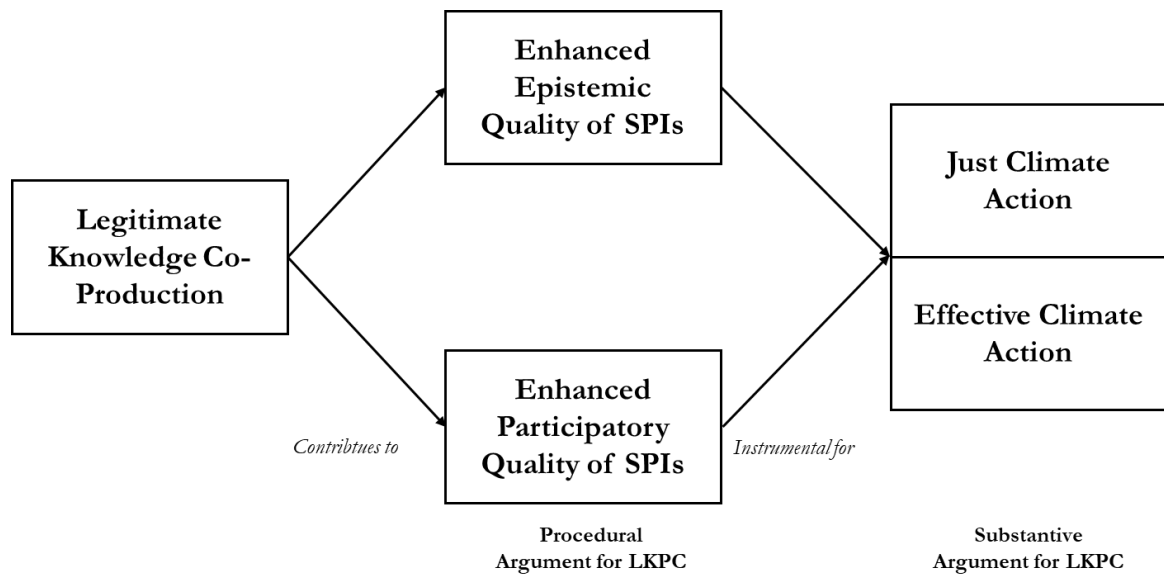
Figure 13: Enhancements of SPIs through LKPC relative to linear and co-production

	Linear Model	Standard Co-Production Model	LKPC
Description	(Scientific) knowledge is one-directionally communicated to decision-making.	Knowledge and policy are co-produced without explicit procedural legitimacy criteria.	Knowledge and policy are co-produced through emphasising procedural criteria of legitimacy.
Epistemic Quality of SPI	Inclusion of diverse perspectives and knowledge is limited which lowers knowledge quality.	(Formal) inclusion of scientific expertise with local knowledge through joint deliberation processes risks lowering knowledge quality.	Meaningful inclusion of scientific expertise with local knowledge through joint deliberation processes enhances knowledge quality.
Participatory Quality of SPI	Decision-making power being concentrated primarily among experts and policymakers, limits possibilities for participation of relevant stakeholders including citizens.	Participation of diverse stakeholders provides avenues for participation despite risks of tokenism and reproduction of power asymmetries.	Meaningful participation of diverse stakeholders throughout the process contributes to joint decision-making, enhancing participatory quality.
Effectiveness of SPI Outcomes	Limited inclusion of perspectives may reduce context sensitivity, and restricted participation may undermine the legitimacy of decisions and their implementation.	Context sensitivity might be reduced due to limited participation, however, co-produced outputs may be effectively anchored and implemented due to the inclusion of powerful stakeholders.	Enhances relevance and context-sensitivity with the perception of legitimacy anchoring outputs for (long-term) implementation among relevant stakeholders.
Justice of SPI Outcomes	May exclude marginalised voices and knowledge, potentially reinforcing existing inequities.		Ensuring legitimacy within knowledge policy co-production procedurally contributes towards more just outcomes.

Table 13: Synthesising comparison of linear model, standard co-production and LKPC

Characterising Legitimate Knowledge Policy Co-Production

For addressing the climate crisis, knowledge and policy need to be brought together with institutions, being called SPIs in this dissertation. In modern societies, the linear model dominates SPI configurations where (scientific) knowledge is one-directionally communicated to decision-making – with a prime example of an SPI largely based on the linear model being the IPCC discussed in Chapter 5 (Beck, 2011).

Given the shortcomings of the linear model for addressing complex sustainability challenges, Chapter 2 showed how the co-production model is dominantly advocated for in the literature on SPIs. In contrast to the linear model, co-production starts with a bottom-up approach by aiming to co-produce knowledge and policy by bringing together scientists, stakeholders, active citizens, and users of knowledge for collaborating as well as "reasoning together" (Kates et al., 2001; Koetz et al., 2012; Wyborn et al., 2019) [105]. Relative to an exclusive focus on scientific knowledge within the linear model, '*knowledge policy* co-production' points to a broader understanding of what encompasses knowledge including local forms of knowledge.

However, as discussed in Chapter 3, this 'standard co-production model' itself has shortcomings with regard to acknowledging the power and politics within its participatory co-production processes (Cornwall, 2002; Lahsen & Turnhout, 2021; Turnhout et al., 2010, 2020). As Turnhout et al. (2020, p.16) note, "outcomes of participatory interventions can even be paradoxical, reinforcing the problems that they intended to solve but now sanctioned or legitimised by the participatory process". Following this line of argument conceptions of co-production often fail to adequately account for power (Wyborn et al., 2019, p.6). For addressing these power-related risks, legitimacy is introduced as a procedural way of enhancing standard co-production through criteria such as transparency, accessibility, accountability, and reflexivity in Chapter 3, leading to the main conceptual innovation of this dissertation, introduced here as LKPC. LKPC is conceptualised as a way of configuring how knowledge and policy can be brought together within SPIs based on further developing 'standard co-production' through adding procedural criteria of legitimacy.

Conceptually developed in Chapter 3 of this dissertation, Chapters 4 and 5 empirically found the importance of the criteria of legitimacy for ensuring meaningful participation and inclusion within SPI processes. With regards to 'process-accessibility', for instance, stakeholders in Accra pointed to the high-opportunity costs of participating, as they were losing a complete day of work while not being paid for the transportation which led to declines in participation within the UCAP creation process there. In contrast, citizens invited to participate in Bonn's civil society process were paid a daily allowance to participate. Next to being paid a

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[105] Co-production, as understood here for conceptualising LKPC, has the explicit aim of co-producing knowledge and policy and stands for participatory methods of knowledge production(Turnhout et al., 2020). It thereby contrasts other meanings of co-production in STS and public administration science (Miller & Wyborn, 2020; Wyborn et al., 2019). In public administration, co-production is defined as "[t]he process through which inputs used to produce a good or a service are contributed by individuals who are not 'in' the same organisation" (Ostrom, 2009, p. 1073) while in STS an example of a conceptualisation of co-production is the following: "Scientific knowledge and political order are co-produced at multiple stages in their joint evolution, from the stabilisation of factual findings in laboratories and field studies, to the national and international acceptance of causal explanations offered by science and their use in decision-making."(Jasanoff et al. 1998, p.6-7).

remuneration for their participation, Bonn's civil society UCAP can be considered as an example of enhancing process-accessibility by reducing physical participation barriers for people with disabilities and translating for citizens whose mother tongue was not German.

Next to process-accessibility, 'reflexivity' serves as an example for illustrating procedural criteria of legitimacy. Chapter 5 on the IPCC, for instance, highlighted that reflexivity among male and white stakeholders contributed to them holding back within the respective SPI processes to ensure that everyone formally participating meaningfully was able to contribute. Through LKPC, it is argued below, the epistemic and participatory quality of SPIs can be enhanced which, in turn, is instrumental for more effective and just climate action.

Enhancing the Epistemic and Participatory Quality of SPIs Through LKPC

Relative to the linear and standard co-production models, it was shown in this research that LKPC enhances the epistemic and participatory quality of SPIs. The epistemic quality of SPIs is understood as the achievement of a more holistic and comprehensive understanding of the contexts of and climate actions themselves, embracing the partiality of knowledge claims to ensure they reflect a plurality of perspectives (Haraway, 1988; Lima & Partidario, 2020; Pickering, 2019).

Contrasting a plurality of perspectives, the linear model relies primarily on scientific knowledge being communicated as singular truth to policymaking (Pielke, 2007; Price, 1981). Hence the integration of diverse perspectives is limited in this model. The standard co-production model risks lowering knowledge quality due to potentially only formally rather than substantively including diverse perspectives. LKPC addresses these limitations by widening the sources of knowledge considered credible inputs for the SPI and highlighting the importance of diverse perspectives and their substantive inclusion through legitimacy criteria. When stakeholders are not only formally present but actively engaged through legitimate processes, their diverse knowledge and perspectives contribute more effectively to the overall understanding of climate challenges and solutions. For instance, in the UCAP creation process in Accra discussed in Chapter 4, stakeholders noted that the exclusion of ecologists significantly decreased the understanding of urban greening's contribution to both mitigation and adaptation. This knowledge gap was further compounded by the lack of female stakeholder participation, which reduced understanding of the gender impacts of the plan.

Next to enhancing the epistemic quality of SPI processes, synthesising the arguments brought forward in this dissertation suggests that LKPC enhances the participatory quality of SPIs as well. The concept of participatory quality emerges from a democratic ideal that fundamentally affirms individuals' right to shape and participate in the structures and processes that directly impact their lives and is understood in this sense

as the extent and manner in which stakeholders are meaningfully integrated into knowledge production and decision-making processes related to the SPI (Bornemann et al., 2022; Copp et al., 1995)[106].

In the linear model, decision-making power is concentrated primarily among experts and policymakers, which inherently limits the possibilities for the participation of relevant stakeholders, including citizens. This concentration of power creates risks of science and related ideals of 'universal scientific knowledge' being used to impose decisions without proper democratic deliberation (Bogner, 2021; Strohschneider, 2024; Weber, 1946).

Standard co-production attempts to address these participatory shortcomings by including diverse stakeholders in the SPI process, thereby providing enhanced avenues for participation. However, there is a tangible danger that such collaborative processes could be co-opted by narrow, well-organised interests or other powerful stakeholders within the SPI process, potentially undermining the democratic ideals of genuine participation. Given that participation does not equal inclusion, there are risks of tokenism and reproduction of power asymmetries.

LKPC aims to mitigate these risks by ensuring meaningful participation of diverse stakeholders throughout the SPI process by procedural criteria such as reflexivity and process accessibility. LKPC transcends mere consultation, representing a substantive mechanism for democratising knowledge production and political decision-making processes. With this, LKPC counters risks of the "epistemisation of the political realm" (Bogner, 2021), leaving questions of societal transformation processes to experts without societal and value-based deliberation, and contributes to enhancing the participatory quality of the SPI process. In turn, this is expected to contribute to more effective and just climate action as laid out below.

LKPC for Contributing to Effective and Just Climate Action

Based on the enhanced epistemic and participatory quality of SPIs through LKPC, the pragmatic and moral arguments for LKPC posit that LKPC contributes to more effective and more just climate action relative to the linear and standard co-production models. Effectiveness for this purpose is understood as the ability to design and implement climate actions that are context-sensitive and actionable (Hogl et al., 2012; Mena & Palazzo, 2012).

Restricted participation in SPIs following the linear model might undermine the legitimacy of decisions and their implementation while reduced epistemic quality may contribute to reduced context-sensitivity for both the linear and the standard co-production model. This was seen, for instance, in Ahmedabad's UCAP creation process which resembled characteristics of the linear model. It relied on pre-defined measures from a 'basket of solutions' and was designed with limited stakeholder engagement. Next to being the subject of

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[106] The definition of participatory quality used here refers to both knowledge production and decision-making processes because SPIs and their outputs vary considerably in their direct relationship to political decision-making - ranging from outputs functioning as knowledge bases such as the IPCC's assessment reports to those directly shaping policy implementation such as the UCAPs discussed in this - they invariably embody a profound political dimension of knowledge construction

critique of reduced context-specificity, many stakeholders interviewed for this case study, despite being listed as authors of the UCAP pointed out that they either did not know about the UCAP or did not believe it would be put into practice, pointing to the reduced likelihood of it actually being implemented.

Expanding the participation of key stakeholders to meaningful engagement of a more diverse set of participants through criteria of legitimacy, LKPC contributes not only to climate action to be tailored for its specific context but by increasing the legitimacy of SPI processes through meaningful participation for policymakers to feel ownership, for citizens to feel engaged, and for ensuring public acceptability, arguably contributing to an increased likelihood of SPI outputs actually being implemented. For instance, Chapter 5 showed that policymakers at the UNFCCC level find that enhanced levels of participatory and epistemic quality of the IPCC contribute to increased levels of ownership – with interview partners highlighting the importance of more knowledge from and about the African continent for the IPCC being more context-specific which in turn would contribute to increased ownership from local policymakers and increase its effectiveness.

That effectiveness improvements, however, do not necessarily translate into more justice can be illustrated with the standard co-production model. Lacking procedural characteristics for ensuring the meaningful inclusion of diverse stakeholders, the views of powerful stakeholder groups could be strengthened which arguably could enhance the likelihood of outcomes being actually implemented. These potential improvements of effectiveness, however, would come at the cost of those most vulnerable dismissing marginalised views, interests and knowledges for designing climate action within the SPI process. Because of the distributive implications of climate action, failing to include the knowledge of those most vulnerable to the consequences of climate change in the design of climate action might have important justice implications, potentially reinforcing existing inequities.

In contrast to the standard co-production model, LKPC can serve as the procedural foundation for just climate actions[107]. Because the quality of processes is asserted to be strongly interlinked with the quality of respective outcomes, Chapter 3 introduced LKPC as the procedural groundwork for achieving justice and thereby enhancing SPIs. This point of legitimate processes contributing to more just climate action can be exemplified by Accra's UCAP creation process and its lack of female participants which led to the fact that no gender assessment had been carried out. This lack of meaningful inclusion possibly exacerbates the disproportionate effects of climate change on women, presenting a case of how more meaningful inclusion could have contributed to more just climate action. Following a similar line of argument, the increasing participation of scholars from the Majority World and female scholars in the IPCC sheds light on areas of climate action previously unaddressed. With this procedural enhancement within the IPCC, the IPCC is ultimately expected to contribute to more just climate actions.

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[107] . This understanding of justice highlights the distributive dimension of justice, with conceptions of what is termed procedural or epistemic justice being captured through what is introduced as LKPC in this research (Fricker, 2007; Medina, 2013; Tyler & Allan Lind, 2001).

Challenges and Opportunities of LKPC

Having shown how LKPC contributes through enhancing the epistemic and participatory quality of SPIs to more effective and just climate action, it is important to acknowledge the risks and challenges coming along with this approach. This section first points to some of these challenges before pointing to the opportunities of LKPC.

The main challenge for moving from standard co-production towards LKPC remains unequal power relations in sustainability transformations. Because a legitimate SPI process might shift power from those more powerful towards those with less power, resistance in some cases is to be expected (Pickering et al., 2022; Turnhout et al., 2020). While being a serious challenge, this power challenge does not make LKPC less valuable but rather highlights that actors aiming to design legitimate SPI processes need to be aware of possible backlashes. For overcoming this expected resistance, challenging modern conceptions of objective and neutral science for a singular truth is epistemically as desirable as it might seem counterintuitive at first sight. In this regard, Lahsen and Turnhout (2021, p. 1) find: "The blockage created by these countervailing forces are shielded from scrutiny and change through retreats behind shields of neutrality and objectivity, stoked and legitimated by fears of losing scientific authority", pointing to powerful actor's using the perception of science as apolitical for maintaining the status quo.

Arguing for epistemic pluralism instead of relying only on one form of knowledge for addressing sustainability challenges within LKPC, the resulting knowledge plurality might be misused by climate denialists and other actors with a politically motivated interest in discrediting the scientific findings on anthropocentric climate change, as highlighted in Chapters 3 and 5. While these concerns need to be taken seriously, epistemically as well as morally these concerns should not suffice for not pursuing LKPC.

Next to epistemic and justice-related arguments for LKPC, participatory arguments for LKPC have been introduced under the assumption of general desirability of participation – lacking critical reflection on whether this desirability of participation holds across stakeholder groups and contexts. In this regard, literature on participation points to the importance of recognising different social and political ideals, historical contexts, and different motivations for participatory processes, often varying significantly with social position within the respective society (Min, 2009; Sass, 2018; Turnhout et al., 2010). This point of critique needs to be addressed by carefully adjusting the respective SPI process to its respective context.

Mentioned under 'stakeholder fatigue', the literature additionally points to negative past experiences in participatory processes where stakeholders' contributions were undervalued or ignored, resulting in a reluctance to further engage in participatory or co-productive processes (Gardner, 2005; Mendola et al., 2022). Instead of being a challenge to LKPC, it rather points to the importance of meaningful inclusion LKPC aims at contributing to.

Related to the participatory and inclusive nature of LKPC, there is another concern regarding LKPC's effectiveness the approach holds promise for. The emphasis on inclusivity may slow down decision-making processes, particularly when actors within SPIs strategically use calls for broader participation to delay

progress. In highly pluralistic or polarised contexts, inclusivity can contribute to decision-making deadlocks, where divergent perspectives hinder the ability to reach timely and actionable agreements (Higashi, 2022; Lelong et al., 2017). Observing the UNFCCC negotiations for the research discussed in Chapter 5, this became particularly evident. Because in the UNFCCC process every country (formally) has a voice, the inclusivity of this process has been misused to block progress. These challenges underscore the need for criteria of legitimacy such as robust conflict management and accountability procedures and reflexivity to mitigate risks to ensure that LKPC enhances rather than undermines the effectiveness of climate action.

It is important to highlight that LKPC remains an ideal model that, in its complete form, has not been fully realised in practice, with different case studies discussed in this dissertation fulfilling different criteria of LKPC. Next to political will, the main challenge for further realising this ideal model is a lack of resources and capacity. As shown in Chapter 2 of this dissertation, well-designed SPI processes are expensive and require expertise. With this, it is no coincidence that it was Bonn's UCAP creation process, situated in the Minority World, which was prepared over two years by two fully employed staff members, with funding available for enhancing legitimacy through translations or daily allowances for instance. However, funding is a matter of priorities, and priorities are a matter of political will. Given the epistemic and participatory benefits of LKPC for more effective and just climate action, there is sufficient argumentative base for funders to provide additional resources for making SPI processes more legitimate and co-productive.

With LKPC being oriented toward fostering just climate actions, it is important to acknowledge the need for deeper, more radical shifts for addressing the climate crisis (Geels, 2005; Scoones, 2016). Just climate actions in their singularity will not be sufficient for these deep and radical shifts needed. However, just climate actions, in aggregate, have the potential to catalyse broader transformative changes, conceptualised for instance as just urban transformations in Chapter 4. These encompass the comprehensive restructuring of social, economic, and political systems needed to address climate change and its underlying justice implications (Ernst et al., 2016; Fazey et al., 2018).

Applied for urban policy creation processes at the local level and for a formalised SPI organisation at the international level in the realm of climate change, this dissertation showed how LKPC was applied at multiple scales as well as to different types of SPI in Chapters 4 and 5 for contributing to just climate actions, which in turn are expected to contribute to a just climate transformation. Following the theoretical framework developed in Chapter 3, the ambition of LKPC is to provide a more general model for knowledge policy processes for societal transformations across scales, SPI types and thematic areas, extending beyond climate change to other areas of sustainability decision-making.

Improving the epistemic and participatory quality of SPI processes for more effective and just climate action, cannot only contribute to catalysing broader sustainability transformations but could have important democratic benefits, the literature on democratic participation and sustainability transformations argues (Arias-Maldonado, 2022; Bornemann et al., 2022; Fahrmeir, 2020; Fischer, 2022; Hammond, 2020). Next to fostering public awareness of complex issues related to climate change, by adding procedural criteria to co-production, LKPC can contribute to (re-)gaining trust in democratic structures (D. Otto et al., 2023;

Weymouth et al., 2020). Enhancing SPIs through LKPC, hence, has the potential to contribute to fostering democratic trust and engagement in tackling complex societal challenges for more just sustainability transformations, in climate action and beyond.

6.2 Situating this Thesis Within its Own Framework – Reflections on Limitations

This section aims to situate this dissertation within its own framework to show how the production of the research presented here rather contradicts than aligns with the ideals of the LKPC framework presented and argued for in the previous section. Reflecting on the extent to which different aspects of LKPC are fulfilled in this research I begin with examining the inclusivity of knowledge referenced in this research, move through the extent this research has been co-produced as well and consider the accessibility of the research production process as well as how power asymmetries have been reflected upon and possibly reproduced. By highlighting these contradictions and potential hypocrisies, this section adds to the methodological limitations pointed out in the Introduction (Section 1.4), providing a critical perspective on this dissertation more specifically and academic knowledge production more generally. With this analysis, the section underscores the importance of path dependencies, stressing the difficulties of changing institutions from within.

Overrepresentation of Male, Western Scientific Knowledge in This Research

Despite describing ideals of inclusive knowledge production considering multiple knowledges from different groups of scientists and other knowledge holders, with this research I inadvertently contribute to the general overrepresentation of male and Minority World perspectives in scientific knowledge production (Collyer, 2018). This is evidenced in the bibliography of my dissertation. Table 14 represents a probabilistic estimate of the gender and ethnicity of the authors cited here based on first names and surnames, which shows that the knowledge reproduced in this research is predominantly male and Western[108]. Notably, in Chapters 4 and 5, written later in the dissertation process, there is a slight decrease in the dominance of Western authors cited. This shift might reflect the thematic focus of these chapters on the one hand, on the other it might point to my growing awareness of the hegemonic structures within academia[109].

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[108] Acknowledging that this probabilistic method does not do justice to individual authors, it is useful for showing that in all four chapters there is a dominance of male and Western authors in each chapter.

[109] Section 6.3 reflects on this growing awareness

		Chapter 2	*Chapter 3*	*Chapter 4*	*Chapter 5*
Gender	*Female*	43.46	44.59	45.97	45.27
	Male	56.54	55.41	54.03	54.73
Ethnicity	*American Indian*	0	0.62	0	1.32
	Asian	6.88	5.26	11.44	7.05
	Black	5.94	4.33	9.45	11.89
	Hispanic	5.62	3.72	4.98	5.29
	White	81.56	86.07	74.13	74.45

Table 14: Probabilistic estimate of gender and ethnicity of authors cited in this dissertation[110]

Despite this awareness and efforts to address these imbalances, path dependencies of the science system remain challenging to overcome. For example, the systematic literature review in Chapter 2 relied exclusively on English-language, peer-reviewed literature, excluding non-English publications and grey literature such as UN reports, which are particularly relevant for SPI research. While this approach aligns with common academic practices, it resulted in 57% of references being attributed to authors with male first names and 82% to authors with Western names.

The prioritisation of male and Western knowledge extends beyond infrastructure and is deeply embedded in Western university education. As noted in the methodology section, my academic background in Philosophy, Politics, and Economics heavily influenced Chapter 3, which focuses on legitimacy, drawing from SPI literature. Legitimacy, rooted in Western governance theory, inherently reflects knowledge originating in the Minority World and is thus subject to critique. Chakrabarty (1992, p.3) notes: „Social science has produced theories that embrace the entirety of humanity. [However], these statements have been produced in relative, and sometimes absolute, ignorance of the majority of humankind – that is, those living in non-Western cultures". While I intended to conduct this social science research with a focus on legitimacy not in ignorance of the majority of the world, I acknowledge the inherent difficulties related to the systemic path-dependencies of academia as well as my and my co-authors (Wester-shaped) positionalities.

The Quest for Objectivity and Reproducing the Linear Model in this Research

The hegemony of male and Western epistemologies within contemporary scientific paradigms is intrinsically tied to feminist and post-colonial critiques challenging the construct of objectivity. Scholars such as Haraway (1988) advocate for situated rationality, challenging the traditional notion of detached, universal scientific knowledge. While I have increasingly embraced this critical stance and acknowledged my own positionality in this research, the general societal expectation for research to appear „objective" and „detached from

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[110] Estimate based on Gender Balance Assessment Tool of Sumner (2018) using data sets of Kaplan (2019) and Mullen (2014) based on historical data to predict gender and race from names.

context" remains a persistent challenge. This tension reveals the deep entrenchment of such norms in academic practices, despite their limitations.

One clear instance of this tension is the selection of case studies for Chapter 4. As outlined in the introduction, the study locations were predetermined by the 'One Health and Urban Transformation' research project that employed me for this PhD. However, adhering to conventional scientific practices, Chapter 4 does not explicitly state this predetermination. Instead, it presents selection criteria such as 'regional variety' and 'democracy,' which create an impression of objectivity. This approach, I learnt is very common: At the ECPR Joint Sessions 2024 workshop on sustainable city governance, I discovered that many presenters faced similar challenges, retrospectively constructing selection criteria to justify case studies that were, in fact, predetermined. This reveals how deeply rooted the expectation of objectivity remains in academic practices.

The broader assumption that scientific knowledge is inherently 'purely objective' also reflects the conceptual alignment with the linear model of knowledge-policy interactions. While this dissertation advocates for legitimate co-production as a more inclusive and collaborative approach to knowledge production, the research itself was conducted in a largely linear manner. Its design was developed primarily in an office setting, with guidance from my supervisors but limited engagement with stakeholders. Following the design, I conducted interviews with researchers, policymakers, and civil society representatives, relying on a one-time, one-directional method rather than engaging in iterative processes of knowledge co-production.

This methodological approach echoes critiques, such as those raised by Bilgen et al. (2021), who argue that a colonial gaze persists in the academic practice of "going to the field to extract knowledge". Such approaches often treat the field as a site for one-sided knowledge collection rather than as an opportunity for collaborative engagement. In this context, my reliance on a largely interview-based method reflects the entrenched challenges of moving beyond conventional practices toward more co-productive approaches. Notably, project funding was available for stakeholder engagement workshops both before and after the fieldwork. However, concerns about flight-related emissions made it difficult to justify the environmental impact of workshops that would have lasted only half a day each[111]. To address some of the gaps in stakeholder engagement, I plan to conduct webinars to present policy briefs in each study country. These webinars, while an improvement, still fall short of the ideals of jointly co-producing policy-relevant knowledge, as envisioned through the lens of LKPC in this dissertation.

This experience highlights the persistent tension between idealised co-productive methods and the systemic path dependencies of academic research. Despite my intentions to challenge traditional models of objectivity and promote more inclusive knowledge production, this dissertation reflects the challenges of fully overcoming these entrenched norms and practices within existing academic and institutional structures.

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[111] Discussed further in Section 6.3

Inaccessibility of This Research and the Broader Science System

Accessibility is a crucial component for enabling substantive participation in SPI processes following the LKPC model. It ensures that stakeholders can actively engage in knowledge creation and comprehend the outputs produced. However, this dissertation, situated within the broader science system, contrasts with the ideals of LKPC, in several significant ways, reflecting systemic barriers to accessibility. One of these barriers is financial, reinforcing the inaccessibility of academia. For example, Chapter 2 of this dissertation incurred an open-access publication fee of approximately $5,000[112]. Such exorbitant article processing charges, coupled with the profit-driven nature of academic publishing, exacerbate inequities in global knowledge production. These costs make publishing - and, consequently, contributing to academic discourse - unattainable for many researchers from lower-income institutions.

The financial constraints extend beyond publication fees. Travel costs to conferences, journal subscription charges, and participation fees for workshops also create barriers for researchers, particularly those from less privileged backgrounds. While academic research in sustainable development is organised globally, my position as a German passport holder and my base in Germany provided me with distinct advantages. Many relevant conferences took place in European countries where I did not require a visa, and travel expenses were comparatively low. These structural privileges underscore the disparities faced by researchers from different parts of the world.

While it is beyond the scope of research including this dissertation to address these structural inaccessibility factors comprehensively, it is essential to acknowledge their existence. The systemic barriers within academia are not only reproduced but may also be inadvertently legitimised through research like this. Recognising these inequities is a necessary step toward advocating for a more inclusive and accessible science system.

Reflexivity

Reflexivity about power asymmetries and strategies for mitigating them was emphasised as a cornerstone of LKPC. While advocating for reflexivity is straightforward in theory, reflecting on the inherent power imbalances within this research reveals the complexities and challenges of addressing them in practice. As a researcher, I hold power in multiple ways, including the selection of research topics and methodologies (Wolf, 1996). Additionally, my positionality as a WEIRD researcher compounds this power, shaped by the privileges I hold. Though a comprehensive analysis of these dynamics is beyond the scope of this subsection, two key examples illustrate how power imbalances have manifested in this research.

The first example concerns the selection of study countries. As a Western researcher conducting fieldwork in the Majority World, I followed a pattern common in many development research institutions. My colleagues from Germany and I primarily conducted research in countries in the Majority World, while many colleagues from the Majority World studied their home countries. This pattern reflects a broader trend

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[112] The publisher Elsevier, where two of the four publications of this dissertation are published, made $1.8 billion in journal revenue with a 37% profit margin in 2017 (Buranyi, 2017; Butler et al., 2023).

described by Bilgen et al. (2021) who critique the unspoken rule within institutions like ZEF, where researchers from the Majority World are expected to study their home countries as "insiders" while researchers from the Minority World are encouraged to observe the Majority World as "outsiders". This dynamic perpetuates the perception that Minority World researchers are "neutral observers" while Majority World researchers must act as cultural intermediaries, reinforcing hierarchical notions of expertise and legitimacy (ibid., p.7).

The second example concerns research partnerships. Each case study involved formal partnerships with local research institutions. While the term 'partner' implies equality, the reality often reflects significant power imbalances. My institute initiated these partnerships, set the research agenda, and provided the majority of the funding. During field visits to Accra and São Paulo, the partnerships largely entailed logistical support, such as access to office space in university departments only tangentially related to my research. The situation in Ahmedabad contrasted with these experiences. Seeking stronger institutional embedding, I was fortunate to collaborate with Professor Minal Pathak of Ahmedabad University, an IPCC author with expertise in urban climate change and an interest in this research. This collaboration was markedly more equitable, as she guided my research, co-authored the resulting publication, and actively contributed to shaping the project's direction. While this experience demonstrates that proactive measures can help mitigate certain power asymmetries, my ability to take these steps was itself influenced by my positionality and privilege.

These examples underscore the inherent power asymmetries embedded within academic systems. While mitigating these imbalances entirely may be impossible, they highlight the critical importance of awareness and intentional action to address and reduce such inequities wherever possible. Recognising and challenging these dynamics is an essential step toward fostering more equitable research practices.

6.3 Academic, Societal and Political Contributions - Reflections on How This Research (Might Have) Shaped Me and My Environment

In this subsection, I reflect on the contributions of this thesis. Rather than merely listing the conceptual, empirical, and methodological achievements, I aim to embed the academic contributions within a broader context - exploring how this dissertation has already influenced me and my environment over the past three years, as well as reflecting on this research' potential political and social contributions. Following up from the positionality statement of the introduction, this section begins by examining how this research has shaped me, enabling readers to trace my reflections on how I believe the dissertation might have influenced my environment. After retrospectively examining the research's impact up to the point of writing this frame text, a forward-looking approach is adopted, describing the dissertation's academic contributions and its potential significance beyond the academic realm.

Shaping Me: Reflections on My PhD Journey

In the positionality statement in the introduction, I have reflected upon my past experiences for the reader to understand how this research has been shaped by my upbringing, my academic education, and my climate activism. Here I describe how the past three and a half years of working on this project, living across four continents and becoming acquainted with academia have been transformative for me. Next to introducing the reader to my intellectual journey, the purpose of these reflections is for the reader to situate the contributions of this dissertation described thereafter.

Living in Ghana, Brazil and India for the data collection for Chapter 4, I acquired a new understanding of colonialism for understanding debates within the realm of climate change. Especially in Ghana, it was the visible legacies of colonial suppression, exploitation, and the transatlantic slave trade, evidenced by over 40 slave castles along the former 'Gold Coast'. This prompted deep reflections on global justice and the enduring impacts of colonialism – reflected a.o. in Chapter 5 on the IPCC and its framing of modernity and unlearning it.

Next to my deepening understanding of colonialism, my research journey also prompted a profound re-examination of my relationship with scientific knowledge. Despite having taken a course in philosophy of science during my undergraduate degree, when starting with this research and developing the first draft of the research proposal, was the first time I started questioning my previously unquestioned trust in what constitutes 'science'. I began to critically examine slogans like 'unite behind the science', often used by the climate movement, increasingly recognizing that such statements fail to address crucial questions about whose science we should unite behind and for whose benefit.

Additionally to questioning the notion of objective and neutral science, I learnt about all the accessibility barriers of the science production system including the enormous article processing charges and inequities in research funding mentioned in the section above, starting to appreciate the concept of "undone science" by Hess (2016) to highlight the scientific research that remains unproduced or underfunded.

Reflecting on these systemic issues, I began to question the general trust that both I and society place in science for finding solutions to the climate crisis. I started contemplating the nature of scientific knowledge: who produces it, under what conditions, and for what purposes. In line with these questions, I came to believe that acknowledging one's interest in a more climate-just world should be a moral imperative, contrary to perspectives arguing that researchers working on climate-related issues should remain detached from their subject[113].

Drawing parallels with other fields like gender studies, where researchers often openly align with feminist ideals and no one would ask them to not have an interest in a more gender-equal world (Wolf, 1996), I started to embrace the idea that my research could and should be driven by ideals of climate justice. This shift in perspective led me to seek synergies between my research and activism, rather than trying to strictly

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[113] For instance, Büntgen (2024) in an article titled 'Why climate scientists should not be climate activists'.

separate them. In practice, this meant I started researching as an embedded observer, using the insider perspective from my climate activism at the international level to inform my research on the one hand, while on the other hand using insights from my research to inform my activism.

It's important to note that while I learnt to appreciate synergies between research and activism, I maintain a critical stance towards scientists who use the societally perceived high credibility of scientists to speak „for the science" in a way that suggests politics and society should simply follow scientific directives which might seem without alternative. In contrast, having thought and analysed the quality of processes for three years theoretically and empirically at different levels has underscored the crucial importance of the link between processes and outcomes, I developed a new appreciation of well-designed processes for enabling better outcomes through the PhD. This has been described overarchingly in the conclusion of this project as the link between LKPC processes for just climate action outcomes. Responses to climate change cannot be solely determined by science but must emerge from legitimate processes that give voice to diverse stakeholders, enabling equitable climate solutions.

Shaping My Environment – Reflections on How This Research Might Have Shaped My Environment

The research presented here, encompassing both the activities I undertook directly related to it and my interactions with the surrounding environment, has shaped this environment in various ways. In this subsection, I reflect on how this research influenced interview participants and research sites, as well as on specific projects that emerged from reflections directly related to my PhD. Before delving into these reflections, it is evident that my research, alongside collaborations, interactions, and discussions with colleagues and fellow climate activists, has impacted some of the individuals I worked with over the past three years. Rather than speculating on how these individuals might have been influenced by me and my research, I invited several of them to write brief reflections. Five accepted this invitation, and their reflections are presented in *Appendices C-5 to C-10*, offering insights into the diverse ways this dissertation already shaped its surroundings.

Beyond the potential impact on colleagues and fellow climate activists, my research may have influenced participants in the more than 100 interviews conducted for this PhD. While interviews are often conceptualised as linear exchanges where the interviewer collects data from the interviewee, they inevitably trigger reflections through the questions posed and reactions shared during the conversation. Although the extent of such reflections varied among individuals, responses like „Good question, I'll need to think more about that" occurred frequently. For Chapter 5, my interview guide, which explored participants' relationships with and understanding of the IPCC, likely prompted reflections on knowledge, science, and the political dimensions of the IPCC.

Similarly, in Chapter 4, questions about the legitimacy of specific policymaking processes - such as inclusivity, accessibility, and transparency - encouraged policymakers to consider how future processes could

be improved. Notably, during interviews in São Paulo and Ahmedabad, which followed my earlier research in Accra and Bonn, I was sometimes asked for recommendations based on observations from my previous study. In these cases, I was perceived as an expert with global insights, and interviewees sought my advice for addressing similar challenges within their respective contexts. These experiences underscored the tangible impact of my research on interviewees, shaping their thinking and potentially influencing future climate policy practices.

In addition to these direct interactions, it is worth noting that many interview participants were initially contacted via LinkedIn, where we remain connected. Through LinkedIn, Twitter, and Instagram, I share research insights via posts, videos, and blog entries (see Appendices C-1 to C-4 for examples). These platforms extend the reach of my research, reaching not only interview participants but also thousands of other viewers.

Beyond the intentional or unintentional impact on interviewees, colleagues, and social media audiences, my research journey - described in the preceding sections of this dissertation - led me to seek synergies between research and activism. A notable example of this integrated approach was my involvement in the Global Stocktake (GST) process at the UNFCCC level[114]. As a member of YOUNGO's GST working group and the cross-constituency GST working group, I collaborated on formal written submissions to the UNFCCC, delivered interventions during negotiations, and engaged in bilateral discussions with government negotiators. This experience allowed me to apply research insights - such as emphasising transparency and accessibility - to my activism, while my civil society engagement itself offered me valuable inside - perspectives on how knowledge is co-

Figure 14: Me presenting a poster on the legitimate GST

created when civil society representatives, IPCC members and government negotiators are coming together for my research (exemplified in Figure 14 and Appendix C-2).

Moreover, my research has profoundly shaped my understanding of the importance of legitimate and inclusive processes and underscored the need for a decolonial stance. Reflections on the importance of good processes have influenced various aspects of my daily life, including seemingly mundane tasks such as organising a flatmate search or my climate activism. Recognising the procedural challenges faced by young climate activists from the Majority World in participating meaningfully in the UNFCCC negotiations, I also founded the Bed Exchange and Bonn Climate Camp initiatives. These projects aim to lower participation barriers by connecting activists with free accommodation and providing a dedicated space near the UN

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[114] I would like to point to the reflection piece of the working group lead Shreya K.C. about this dissertation impacting the working group in Appendix C-9 here.

climate negotiations for civil society networking, relaxation, and free meals. The Bed Exchange addresses practical accommodation challenges by linking activists with potential hosts. Reflections on the importance of a decolonial stance have also driven me to co-found initiatives such as the 'Decolonising Knowledge Group' at ZEF, a group which envisions a research environment that critically examines colonial legacies, epistemologies, and power dynamics within academia.

Through these initiatives, I have sought to translate theoretical insights from my research into practical solutions, fostering inclusivity and equity in both academic and activist domains. These efforts exemplify how my research journey has shaped my environment, advocating for more equitable practices in knowledge production and climate activism.

Reflections on the Academic Contributions of This Research

After having reflected on how the research presented here has already shaped me and the broader environment, I want to take a more forward-looking approach and assess the academic contributions of the research presented here. In line with the questions mentioned above of 'whose science for whose benefit' related to LKPC, it suggests itself to reflect on what academic contributions mean (Gendron, 2013; Riel & Snyder, 2024). Within the science system, the question of whether this research contributes to academic knowledge is determined primarily by the editors and reviewers of peer-reviewed and indexed journals and is often related to impact factors[115].

Balancing impact factors, journal processing times and available funding options, the chapters of this dissertation have already been published in peer-reviewed journals – and with this are individually expected to advance the academic literature, specifically the literature on climate governance and SPIs. While the individual contributions of Chapters 2 to 5 have been laid out in the introduction and each of the chapters, this section aims to jointly consider these contributions, structuring these by the conceptual, empirical and methodical contributions of the research presented here.

Conceptually, the main contribution of this research is the development of the LKPC as a novel approach for integrating knowledge and policy to address climate change in a more effective as well as just manner. Building on and extending the existing literature on SPIs, the LKPC framework highlights that SPIs are not neutral nor apolitical entities but require the justification of their power and emphasises the importance of legitimacy in knowledge co-production processes. Embedded within a critical view of modernity, the framework is based on literature from STS, post-colonial theory and political theory to provide a comprehensive set of criteria across input, throughput, and output dimensions of legitimacy, offering a tool for evaluating and enhancing the quality of SPIs.

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[115] The degree to which the respective research advances the literature is often related to the impact factor of the journal the research is published within, noting that this focus solely on impact factors has been criticised to disregard the often-higher publication costs and processing times associated with higher impact factors (Moustafa, 2015; Triggle et al., 2022; Wanzala, 2018).

Empirically, the dissertation makes two main contributions. A key empirical advancement is the comparative analysis of UCAP creation processes in four global cities, which not only illuminates differences in how these plans are developed but also highlights the pivotal role of city networks in shaping local climate action planning. Additionally, Chapter 4 provides insights into the practical application of legitimacy criteria in diverse urban contexts for climate action planning processes. On the international level, the research offers a modernity-critical perspective on the IPCC, based on interviews with IPCC scientists and policymakers. The insights from this research shed light on the complexities of knowledge-policy interactions at the global level, revealing both persistent modernist influences and emerging efforts to transcend these limitations. Together, these empirical contributions provide a rich, multi-scalar understanding of how knowledge and policy intersect in addressing climate change, from local to global levels.

Methodologically, this research combines various methods, including systematic and integrative literature reviews, semi-structured interviews, and document analysis complemented by event ethnography, with this contributing methodologically to the literature. The main methodological innovations of this dissertation are connected to technological advancements during the time of this research. These technological advancements not only raise important ethical questions, as discussed in the Introduction but are also transforming academic research practices. This research demonstrates this transformation through its pioneering use of AI technologies, which were integrated into the research process in three distinct ways: First, AI technology was used to generate personalised interview requests that were sent via letters, emails, and LinkedIn messages since March 2023, representing an innovative approach to participant recruitment in academic research. Second, the analysis of the interviews has been supported by AI-supported transcription and translation services, demonstrating a novel approach to managing multilingual data in multilingual research[116]. Third, as declared at the beginning of this dissertation as well as with the publishers of chapters 3 to 5, AI technology has been used in parts of editing this text to enhance its clarity.

Additionally, related to relatively recent technological advancements, during this research I employed a collaborative fieldnote-taking approach. This involved multiple researchers and civil society actors to capture comprehensive data during lengthy negotiation sessions – innovating a new way of collecting data used by different types of stakeholders in line with the ambition of creating synergies between my civil society engagement and my research.

Social and Policy Relevance of the Research

With the climate crisis being described as the greatest justice challenge of our times at the beginning of this dissertation, I believe that working and researching the topic of climate change and related justice questions renders particular societal relevance – and I wanted my research to be of societal relevance and contribute to addressing the climate crisis. It was for this reason that my decision to pursue a PhD that included fieldwork and related air travel across several continents was not taken light-heartedly. It was the expectation

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[116] Premium service was used in order to ensure data privacy.

that with this research's contributions towards changing structures and institutions, the significant environmental costs (listed in Table 15) would be outbalanced by the benefits[117].

Category	Emission Item	CO₂ in kg
Travel Fieldwork Chapter 4	Flights India	3138
	Flights Ghana	2696
	Flights Brazil	5198
Travel Fieldwork Chapter 5	Flight Sharm El Sheik	1377
	Train Journey to Glasgow	+ x kg
Data Analysis	AI Transcriptions, Translations etc.	+ x kg
Conference Travel	Train Journeys for Academic Conferences	+ x kg
Other	Office heating or AC	+ x kg
	Local Transport	+ x kg
Further Emissions	...	+ x kg
Minimum total Sum		**13.158**

Table 15: CO₂ emissions related to the research [118]

Conceptualising these structures and institutions as societal systems in this research, the research is primarily expected to have most of its transformative potential in the academic and political systems. With regard to the academic system, the transformative potential of this research for changing structures within academia manifests in two main ways. First, by illuminating existing power structures in scientific knowledge production and acknowledging that the research itself may potentially reproduce linear ways of producing knowledge and a bias of male and Western science, this research expects to contribute to critical reflections of other researchers.

Secondly, by questioning the universalist principles of science for addressing the climate crisis, the research promotes a culture of research engagement that transcends traditional academic boundaries, arguing that taking a stance on climate change for climate justice is not a violation of the implicit researcher's code of objectivity. Instead, amidst the climate crisis, such engagement, I argue, represents a scholarly responsibility. By challenging the stance of conventional separation between scientific inquiry and active commitment to addressing global challenges, it is expected that this research contributes to inspiring other researchers to critically reflect on their own practices including their academic conference air travel and the associated emissions.

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[117] For retaining 1.5°C of global warming with a 67% probability, there are less than 50 tonnes of CO2 left per person under the assumption of a world population of 8 billion people and a carbon budget of 400 billion tonnes. Distributing this budget in an egalitarian manner is normatively problematic because it doesn't account for historical emissions. Taking the 1.5-degree goal as a reference point, does not imply that 1.5 degrees of warming is safe for anyone; as people lost their lives, homes, and loved ones as well at lower degrees of warming. However, for the purpose of illustrating the point that this research contributed to emissions this suffices (Carbon Independent, 2024; IPCC, 2018a).

[118] C0₂ calculations based on atmosfair's emission calculator (Atmosfair, 2025)

Next to the science system, the political system is critical for shaping societal structures. It is for this reason that this dissertation maintains a specific focus on providing actionable policy recommendations across each chapter. For instance, Chapter 2 provides recommendations for SPI stakeholders, encouraging them to diversify outputs, utilise effectiveness factors, engage in multi-level collaboration, and reflect on institutional design to move towards a co-production model. Chapter 3 includes an action guide (Appendix 3-1) which offers SPI practitioners a structured approach for evaluating and enhancing legitimacy in environmental governance.

Based on these theoretical insides, the research presents policy insights for city network officials and local climate policymakers to enhance the effectiveness and equity of UCAPs, including a practical action guide tailored for legitimately creating UCAPs in Chapter 4 (Appendix 4-1). Tailored towards the IPCC, Chapter 5 concludes with policy recommendations advocating for proactive outreach to underrepresented groups, clear guidelines for including diverse knowledge systems, support mechanisms for meaningful participation, and strengthening meaningful co-creation processes.

Overarchingly, this dissertation contributes by providing actionable insights for enhancing the legitimacy of SPIs across multiple scales of climate governance. It offers practical guidance for transforming SPIs towards more legitimate co-productive models that can contribute to more just climate action. By emphasising the importance of diverse knowledge systems, participatory processes, and reflexive institutional design, the research supports policymakers and practitioners in developing more just and effective climate action plans. These contributions aim to contribute to bridging gaps between knowledge and policy, fostering improved knowledge-policy interactions that can lead to more just climate action in the face of the climate crisis.

6.4 Concluding Remarks

With climate change represents one of the most pressing challenges of our time, with far-reaching consequences for biodiversity, peoples, and cultures worldwide (IPBES 2019; 2022; IPCC 2022), SPIs are important institutions that integrate knowledge and policy to tackle this crisis (Sarkki et al., 2015; Young et al., 2013). Building upon four publications, this cumulative dissertation explored how SPIs can be enhanced to foster just climate action. It systematically summarised existing literature on SPI enhancement, introduced a conceptual framework that emphasises legitimacy and examines how SPIs operate at both local and international levels, particularly in the creation of UCAPs and the workings of the IPCC.

Synthesising the findings of these publications, this dissertation has proposed a procedural framework for fostering just climate actions, termed LKPC. LKPC was introduced to embrace the need to unlearn the entrenched modern dichotomy between knowledge production and policymaking and the linear interaction between both spheres by iteratively engaging diverse stakeholders in meaningful co-production processes. Developing upon standard co-production processes, LKPC is adds procedural characteristics such as reflexivity, accessibility, and transparency to co-production processes. These characteristics, it was argued, are essential for *legitimate* co-production for enhancing the epistemic and participatory quality of SPIs and

thereby fostering effective and just climate action. Epistemically, LKPC broadens the range of credible knowledge sources and integrates diverse perspectives to overcome the partiality of knowledge claims. In terms of participation, LKPC deconstructs the modern notion of universal scientific authority, opening spaces for deliberation and meaningful stakeholder engagement in knowledge production and policymaking. This does not only make resulting climate actions more context-sensitive but through fostering broader buy-in and ownership among stakeholders, contributes to the effectiveness of climate actions. Further, by prioritising the needs of the most vulnerable, LKPC enables more just climate actions.

While power has been highlighted as an important motivation for moving from standard co-production towards LKPC, Chapter 3 does not offer a systematic way of analysing power relationships within SPIs and could be conceptually developed by future research. Following the research presented in Chapters 4 and 5, an application of this power analysis in SPI processes on both the local and the international level would be valuable to shed light on powerful actors in shaping urban and global climate governance.

Despite advocating for LKPC as a pathway to fostering just climate actions, this dissertation acknowledges its own limitations in aligning fully with the ideals of LKPC. The dominance of male and Western authors in the references, the reproduction of a linear model of knowledge-policy co-production, and the systemic power imbalances inherent in the science system highlight the difficulties of transforming institutions from within. Nevertheless, this dissertation has demonstrated its transformative potential by advancing the SPI literature by introducing a legitimacy-based approach to evaluating SPI quality and promoting a culture of engaged scholarship that transcends traditional academic boundaries. It has been argued that addressing climate change is not only a societal responsibility but also an academic one, calling on researchers to reflect on their positionality and engage critically with the systems they inhabit. Additionally, the dissertation offered actionable policy recommendations for designing or enhancing SPIs, providing concrete guidance for UCAP creation processes and the IPCC's work.

As the world rapidly approaches critical climate tipping points, the window for addressing climate change is getting smaller. The resulting urgency, however, cannot come at the cost of legitimate processes for addressing the climate crisis. Achieving the societal transformation needed for just climate action requires not quick fixes but well-designed, legitimate procedures that uphold justice. Bringing together different stakeholders for legitimately co-producing climate action, LKPC offers a promising pathway for enhancing SPIs for addressing the complex justice challenges of climate change.

Afterword

In the foreword of this dissertation, I described the PhD as the result of a transformative journey - one that has filled me with immense gratitude. I want to reiterate the expression of my deepest appreciation to everyone who has accompanied me along this path, as well as to you as the readers of this dissertation, who have followed this journey in hindsight and will carry the insights of this dissertation forward into your spheres of change-making.

While the submission of this dissertation marks a significant milestone, it does not represent an end to this journey. Too many questions remain unanswered, too much curiosity remains to be stilled and too much energy in working towards a more climate-just world remains – with several concrete research initiatives already having materialised along the way.

One key project emerged from our recognition of the need for deeper power analysis in climate action, building directly on the limitations identified in Chapter 3 and applies the theoretical insights to the urban climate action planning processes discussed in Chapter 4. Together with Wendy Chavez and Eric Sebastian Kalversberg, we are expanding Gaventa's (2006) power cube framework by incorporating an epistemic dimension - examining how knowledge and power intersect in urban climate policymaking.

Further, the intersection of cities and climate change has opened another promising avenue of research. Drawing on insights from Chapters 4 and 5, I am collaborating with Shaurya Patel and Tasfia Tasnim to evaluate the inclusivity of the IPCC's special report on cities and climate change. Through stakeholder interviews, we already began examining how different voices shape the report from its initial scoping to its final policy recommendations. Complementing this qualitative work, I am supervising Emmanuella Asomani Asante's Master's thesis together with Sara Velander and Lisa Biber-Freudenberger, conducting a quantitative analysis of tens of thousands of comments of governments and experts on the IPCC's assessment reports to understand who influences the IPCC in this crucial phase of science policy interaction of the panel.

However, my primary focus moving forward centres on the United Nations Framework Convention on Climate Change's (UNFCCC) first Global Stocktake (GST) - a crucial mechanism for increasing climate action ambition under the Paris Agreement. I will join a research project at the University of Geneva and IDOS to assess both the inclusivity and effectiveness of this process. Our research will examine how different stakeholders contribute to the GST and, critically, how its outcomes influence countries' mitigation and adaptation commitments through their Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs).

These projects represent just a few of the many possible paths forward from this dissertation. Bringing together epistemic humility - recognizing the inherent limitations of any single perspective - with an unwavering commitment to advancing climate justice, I want to end here by saying that I am looking forward to continuing this journey.

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APPENDICES

Appendices

Introduction

Appendix I-1: Exemplary Consent Form

This informed consent form is for stakeholders of global, environmental Science-Policy Interfaces (SPIs) who we are inviting to participate in two doctoral research projects.

This research will involve your participation in a semi-structured interview and/or survey that will take no more than one hours to complete. You are being invited to take part in this research because we feel that your expertise in SPIs can contribute significantly to our understanding on the challenges SPIs face related to the extent of legitimacy in their institutional institution and the complexity of the issues they aim to address.

Your participation in this research is entirely voluntary and no compensation will be offered. Please share only what you are comfortable with sharing. You may decline to participate, or you may choose not to answer any particular questions that I ask. If you change your mind about participating, you may stop the interview or your involvement in the study at any time. The information recorded is confidential, and no one else except our supervisors will have access to the information documented during your interview. The entire interview will be recorded, but no one will be identified by name on the recording, unless consent was obtained. The interview recording will be kept in an external hard drive and a private online folder (OneDrive). You have the option for removal of the recording and transcriptions after the research is completed.

We will keep all facts about you private. We will keep your identity anonymous unless you give explicit permission below to use your name. If you prefer to remain anonymous, any information about you in the publications of our findings will have a number on it instead of your name. Only we and our supervisors will know what your number is, and we will store that information in the external hard drive and private, OneDrive folder. Nothing that you tell us today will be shared with anybody outside the research team, and nothing will be attributed to you by name. Each participant will receive a summary of the results. We will give you an opportunity at the end of the interview to review your remarks, and you can ask to modify or remove any portions you do not agree with or if I did not understand you correctly.

Please feel free to contact either of us or our supervisors if you have any questions, concerns or comments about the study.
Thank you!

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This research proposal has been reviewed and approved by the ZEF Research Ethics Board, committee that ensures research participants are protected from harm. If you wish to find out more about the REB, please contact zef.ethics@uni-bonn.de**.**

Certificate of Consent

I have read the aforementioned information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study.

Permission to use the following in publications:

☐   Name of Organization (IPCC for instance)   If yes, please specify   _____

☐   Name of Department or Working Group   If yes, please specify   _____

☐   Stakeholder type   If yes, please specify (multiple options possible):

            ☐   Policy Maker

            ☐   Scientist

            ☐   SPI Secretariat

            ☐   Civil society representative

            ☐   Other: _____

         For possible follow ups:

☐   Email-Address   If yes, write it here: _____

Additional comments: (if applicable)   _____

_____

Date (DD/MM/YY):   _____

Participant name and signature: _____

Researcher name and signature: _____

For Internal Use:

Interview Number: _____

Chapter 2

Appendix 2-1: Table of SPIs resulting from the Literature Review

SPI Name	Description (based upon the literature or a web-research)	Study /Source	Level of SPI	Type of SPI
Eklipse project	The Eklipse Project is a research project at the European scale to gather evidence relevant to decision-making by establishing a dialogue between science, policy and society.	(Kelemen et al., 2021)	Regional	Research Project
European Research Projects	Research Projects funded by the European Union in the field of biodiversity and ecosystem services aimed to produce new knowledge, but also to reach out to enhance interactions between science and policy.	(Sarkki et al., 2020)	Regional	Research Project
Flemish research and knowledge center for nature and its sustainable management and use	Flemish research and knowledge center for nature and its sustainable management (INBO) works primarily for the Flemish government and supplies information for international reporting and addresses issues at the level of local authorities.		Local	Agency
Society for Conservation Biology (SCB)	An international professional organisation dedicated to promoting the scientific study of the phenomena that affect the maintenance, loss, and restoration of biological diversity.		Global	Interest Group
Brazilian Platform on Biodiversity and Ecosystem Services (BPBES)	The Brazilian Platform on Biodiversity and Ecosystem Services (BPBES) was founded by scientists („bottom-up") hence without a government mandate to promote biodiversity protection through research and policy interaction.	(Scarano et al., 2019)	National	Interest Group

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)	The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a global research partnership for a food-secure future dedicated to reducing poverty, enhancing food and nutrition security, and improving natural resources.	(Dinesh et al., 2021)	Global	Agency
New Zealand's Natural Hazards Research Platform	The Natural Hazards Research Platform was tasked with bringing major research organizations together with policy and other stakeholders to coordinate research funding and activities in New Zealand's national interest.	(Beaven et al., 2017)	National	Agency
UK Climate Impact Programme (UKCIP)	The UKCIP provides, among other outputs, scenarios and socio-economic projections to policymakers and stakeholders. The UKCIP is principally funded by the government department for environment, food, and rural affairs (Defra) but is hosted at the University of Oxford.	(Hanger et al., 2013)	National	Agency
Flemish Coordination Group of Adaptation to Climate Change	The Coordination Group of Adaptation to Climate Change oversees adaptation planning and implementation and is responsible for the evaluation of the NAS. This coordination body is headed by a ministry, with members from other ministries and national research institutions.		National	Agency
Oficina Española de Cambio Climático	The Spanish Climate Change Office is a coordinating entity within the Ministry of Environment and the National Climate Council, an open and participatory body for approving		National	Agency

	climate change-related programs, policies and plans, where representatives from autonomous regions, municipalities, scientists, and a wide range of stakeholders are represented.			
National Observatory on Climate Change Effects (ONERC)	The National Observatory on Climate Change Effects (ONERC) was established as a coordinating unit in 2001, to collect and spread information, study and research risks related to global warming and disasters, and formulate recommendations on potential preventive and adaptive actions. ONERC is a government agency that cooperates with different research institutions.		National	Agency
Environment Agency Austria	The Environmental Agency of the government of Austria consults decision making on environmental issues at the local, regional, and global levels.		National	Agency
Interministerial Working Group Romania	The inter-ministerial working group includes experts from national research institutes was organized to support the Romanian environmental ministry department responsible for the writing of the national climate strategy.		National	Agency
South African National Biodiversity Institute	SANBI is assigned to monitor the status of the country's biodiversity, report to the Minister of Environmental Affairs, provide science-based policy advice, generate and disseminate information, undertake and promote research as	(S. Koch, 2018)	National	Agency

	well as carry out and coordinate ecosystem programs, among others.			
EU Research Projects	Research Projects funded by the European Union in the field of biodiversity and ecosystem services aimed to produce new knowledge, but also to reach out to enhance interactions between science and policy.	(Tinch et al., 2018)	Regional	Research Project
Society for Conservation Biology (SCB)	The Society for Conservation Biology is a formal, science-driven, international, professional organization that aims to advance the science and practice of conserving the Earth's biological diversity. Efforts have been made to internationalize the SCB by establishing regional sections in Africa, Asia, Australasia, Austral and Neotropical America and Europe. SCB now lists "increasing the application of science to management and policy" as one of its goals and is more active at the science-policy interface by engaging in policy issues at multiple levels of decision-making.		Global	Interest Group
The Economics of Ecosystems and Biodiversity (TEEB)	The Economics of Ecosystems and Biodiversity (TEEB) was established after the G8 ministers called for more evidence which was presented then at the 9th conference of the parties (COP) of the Convention on Biological Diversity (CBD). Since 2010 (COP 10) there has been intense outreach including a series of workshops across the globe, and TEEB entered its current Phase 3 of		Global	Expert Group

	facilitation and supporting country level implementation.			
Het Instituut voor Natuur- en Bosonderzoek (INBO)	„INBO (Het Instituut voor Natuur- en Bosonderzoek) is the Flemish research and knowledge centre for nature and its sustainable management and use. INBO conducts research and supplies knowledge to all those who prepare or implement policies or are interested in them. As a leading scientific institute, INBO works for the Flemish government primarily, but also supplies information for international reporting and deals with questions from local authorities" (Tinch et al., 2018, p. 1685).		Local	Agency
AfriBES	The AfriBES network is a social network of scientific and technical information on biodiversity and ecosystem services for Africa. It emerged from the consultative process towards an International Mechanism of Scientific Expertise on Biodiversity (IMoSEB). The main goal of AfriBES is to foster better sharing of and access to relevant information on biodiversity, as well as better access to African expertise and experts.		Regional	Expert Group
Arctic Council	Arctic Council was established in 1996 "as a high-level forum to provide a means for promoting cooperation, coordination and interaction among the Arctic States, with the involvement of Arctic Indigenous communities and other	(Spence, 2017)	Regional	Expert Group

	Arctic inhabitants on common Arctic issues, in particular issues of sustainable development and environmental protection in the Arctic."			
Global Environmental Outlook	Environmental Assessment by the United Nations Environmental Programme (UNEP).	(Riousset et al., 2017)	Global	Expert Group
KwaZulu-Natal Sandstone Sourveld (KZNSS) Research Programme	A Research Programme which is part of a collaborative, transdisciplinary research partnership between the University of KwaZuluNatal and the eThekwini Municipality (EM), aimed at bridging the science-policy-practice gap. The research programme focuses on generating knowledge and capacity to support local land-use planning, management and policy development related to biodiversity and climate change issues.	(C. Taylor et al., 2016)	Local	Research Project
Caribbean Regional Climate Outlook Forums (CariCOFs)	CariCOFs facilitate the production of regional seasonal climate information and the dissemination of it to a diverse climate and socioeconomic region.	(Guido et al., 2016)	Regional	Expert Group
Climate Change Impact Maps for Austrian Regions (CLIMAMAP)	Funded by the Austrian Climate Research Programme (ACRP), Climate Change Impact Maps for Austrian Regions (CLIMAMAP) produces maps of the impacts of climate change in a transdisciplinary manner.	(Becsi et al., 2020)	National	Research Project
Multi-Donor Trust Fund for EFI Science Policy Support Facility (PSF) known under	ThinkForest is a European high-level forum on forests bringing together policymakers, the scientific community, and stakeholders.	(Hetemaki, 2019)	Regional	Expert Group

„ThinkForest" from EFI.				
Asia-Pacific Biodiversity Observation Network (APBON)	APBON's mission is to increase the exchange of knowledge and know-how between institutions and researchers concerning biodiversity science research in the Asia-Pacific (AP) region and, thereby, contribute to evidence-based decision-making and policymaking.	(Takeuchi et al., 2021)	Regional	Expert Group
Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to the Convention on Biological Diversity (CBD)	SBSTTA's operating principles is to continuously "improve the quality of its advice by improving scientific, technical and technological input into, debate at, and work of, meetings of the Subsidiary Body and consists of government representatives competent in the relevant field of expertise and other stakeholders."	(Koetz et al., 2012)	Global	Expert Group
State-based climate change adaptation (CCA) program (CliChAP)	The State-based climate change adaptation (CCA) program (CliChAP) aims at introducing systems thinking in practice (STiP) in the praxis of climate change research within the Ministry.	(Grant et al., 2019)	Local	Agency
University of Arizona Cooperative Extension, of the U.S. Cooperative Extension System (CES)	A research project based at a University with the vision to be a vital national leader in creating and applying knowledge to help people build thriving, sustainable lives, communities and economies through politics.	(Brugger & Crimmins, 2015)	Local	Research Project
Second Dutch Delta Committee	The Dutch Delta Committee consists of representatives of science, politics, policy and industry and is a state committee that advised	(Boezeman et al., 2013)	National	Agency

	the Dutch government on adapting to climate change in 2008.			
Alaska Fire Science Consortium	Alaska Fire Science Consortium focused on fire science and management in Alaska that is working to address climate impacts on wildfire.	(Colavito et al., 2019)	Local	Research Project
Great Lakes Integrated Sciences and Assessment (GLISA)	A traditional boundary organization funded by the US government to foster climate information use in support of climate adaptation in the Great Lakes region of North America.	(Kirchhoff et al., 2015)	National	Research Project
Marine Life Protection Act Initiative	The initiative guides California's Marine Protected Area (MPA) network planning, based on the best readily available science and engages stakeholders.	(de Santo, 2017)	Local	Expert Group
Regional Projects	„Four stakeholder-driven Regional Projects worked to establish lists of Marine Conservation Zones (MCZs) designed to conserve biodiversity and reconcile socioeconomic concerns." (p.39)		Regional	Agency
Scientific Committee of the International Whaling Commission (SciCom)	The Scientific Committee provides scientific evidence on the exploitation of whales to the International Whaling Commission and is the single global authority on cetacean science.	(Andresen et al., 2018)	Global	Expert Group
Montreal Protocol SAC	„The ozone regime has three scientific assessment panels: these pertain to science, environmental effects and technology, and economy. Since the first set of assessment publications in 1989, the three panels have published periodic evaluations in their respective fields		Global	Expert Group

	every four years. The key findings of the panels for each periodic assessment are synthesized into a short report" (p.5)			
North Sea Regime SAC	The North Sea environmental regime, founded in 1972, is a political regime tasked with setting regulations on toxic waste dumping in the North Sea.		Regional	Expert Group
BiodiversityKnowle dge project	The European Biodiversity Knowledge project is a network connecting different biodiversity projects in Europe.	(Dicks *et al.*, 2016; *Schindler et al., 2016)*	Regional	Research Project
Natural Environment Research Council (NERC) Knowledge Exchange Programme on Sustainable Food Production	A „UK-focused Knowledge Exchange Programme on Sustainable Food Production aimed to identify subjects where research funded by the Natural Environment Research Council could be used to enhance the sustainability of UK food production through impacts on practices in the agri-food supply chain." (p. 1387)	(L. Dicks et al., 2016)	National	Research Project
Scientific Committee of the International Whaling Commission (SciCom)	The Scientific Committee provides scientific evidence on the exploitation of whales to the International Whaling Commission and is the single global authority on cetacean science.	(Ishii & Okubo, 2014)	Global	Expert Group
Baltic Sea Marine Environment Protection Commission (HELCOM)	„An intergovernmental organization and a regional sea convention in the Baltic Sea area. As a regional platform for environmental policymaking, HELCOM was established in 1974 to protect the marine environment of the Baltic Sea from all sources of pollution."	(Tynkkyne n, 2015)	Regional	Expert Group

UNISDR Scientific and Technical Advisory Group (STAG)	The UNISDR Scientific and Technical Advisory Group (STAG) „facilitates contact with the scientific community as key to supporting [disaster risk reduction] decision-making." (p.15)	(Aitsi-Selmi et al., 2016)	Global	Expert Group
United Nations Regular Process for Global Reporting and Assessment of the State of the Marine Environment including Socio-economic Aspects	The Regular Process for Global Reporting and Assessment of the State of the Marine Environment reviews the state of the marine environment, including socioeconomic aspects on a continual and systematic basis by providing regular assessment at the global and supraregional levels and an integrated view of environmental, economic and social aspects.	(Fawkes & Cummins, 2019)	Global	Expert Group
The Policy Interpretation Network on Children's Health and Environment (PINCHE)	The Policy Interpretation Network on Children's Health and Environment (PINCHE) aims to provide „policy recommendations aiming at protecting children's health and environment based on completed scientific research" with a focus on air pollutants, carcinogens, noise, and neurotoxicants. (p.6)	(van den Hazel et al., 2006)	Regional	Research Project
the Integrated Forecast and Reservoir Management (INFORM) system project	A model and Decision support system that incorporates Climate information into hydropower and reservoir operations in Northern California.	(Ziaja, 2019)	Local	Research Project
The Blue Mountains World Heritage Institute (BMWHI)	„Established in 2004 as an independent organization that works with these management agencies to broker and facilitate research and community engagement in support of conservation and management of	(Chapple et al., 2011)	Local	Expert Group

	the Greater Blue Mountains World Heritage Area (GBMWHA)." (p. 662)			
OceanWatch	„The primary role of [the small national not-for-profit environmental organization] Ocean Watch is to advance sustainability in the Australian seafood industry. The members of the organization live and work in regional coastal communities around Australia and undertake projects to enhance fish habitats, improve water quality and minimize environmental impacts." (p.81)	(Shaw *et al.,* 2013)	National	Interest Group
The Northern Agricultural Catchments Council (NACC)	The Northern Agricultural Catchments Council (NACC) is a „ not-for-profit organisationon established by the Australian Government to deliver natural resource management outcomes. NACC has influenced the governance system in which they operate and has both initiated and supported regional adaptation initiatives for improved coastal adaptation outcomes." (p.83)	(Shaw *et al.,* 2013)	Local	Interest Group
Advisory Councils (ACs)	„The main mechanism for interaction of fisheries stakeholders in relation to the Common Fisheries Policy, and for the implementation of an Ecosystem Approach to Fisheries Management (EAFM). It includes Advisory Councils from the North Sea (NSAC), the northwestern waters AC (NWWAC), Pelagic AC (PAC), and Mediterranean AC (MAC)." (p.84)	(Ramirez-Monsalve et al., 2016)	Regional	Expert Group

The UK Climate Change Impacts Programme	The UK Climate Impacts Programme (UKCIP) provides scenarios that show how our climate might change and coordinates research on dealing with our future climate. UKCIP shares this information, free of charge, with organizations in the commercial and public sectors to help them prepare for the impacts of climate change.	(Lorenzoni *et al.*, 2007)	National	Agency
The Scientific Committee on Antarctic Research (SCAR)	„Interdisciplinary body of the International Council for Science (ICSU), and its dual role is to initiate, promote and coordinate scientific research in, from and about Antarctica and the Southern Ocean and to provide independent scientific advice to the Antarctic Treaty System and other bodies." (p.91)	(K. A. Hughes et al., 2018)	Regional	Expert Group
Alaska Center for Climate Assessment and Policy (ACCAP)	The „ACCAP was established as one of NOAAs [Regional Integrated Sciences and Assessment (RISA)] programs in 2007 with the mission to improve the ability of Alaskans to prepare for and respond to climate variability and change. ACCAP partners with scientists, decision makers, and other boundary organizations to advance climate science, integrate research and decision support tools, and inform climate adaptation planning and strategies." (p. 9)	(Kettle & Trainor, 2015)	Local	Research Project
Marine Climate Change Impacts Partnership (MCCIP)	The Marine Climate Change Impacts Partnership (MCCIP) was „initiated as a direct response to recommendations in the [State of	(Frost et al., 2017)	National	Agency

	UK Seas] report, to act as a 'neutral clearing house for marine climate change evidence relevant to the UK'." (p.115)			
The Belgian Science Policy (BELSPO) Forum	A „Research Project aimed to decide what kind of model-based decision support is needed to develop policymaking for the transition to a low carbon economy." (p.1)	(Laes & Couder, 2014)	National	Research Project
International Arctic Science Committee (IASC).	A non-governmental, international scientific organization committed to encouraging and facilitating cooperation in all aspects of Arctic research.	(Nilsson, 2009)	Regional	Expert Group
UNCCD SPI	Science-Policy Interface (SPI) of the United Nations Convention to Combat Desertification (UNCCD).	(de Dona, 2021)	Global	Expert Group
ITPS	Intergovernmental Technical Panel on Soils (ITPS) of the United Nations Food and Agriculture Organization (FAO).	(de Dona, 2021)	Global	Expert Group
Collaborative Partnership of Forests - Global Forest Expert Panels	Collaborative Partnership of Forests - Global Forest Expert Panels.	(Humphreys, 2009)	Global	Expert Group
UNEP Risø Center	Boundary Organization of UNEP working on the United Nations Framework Convention on Climate Change Clean Development Mechanism (CDM).	(Lee et al., 2014)	Global	Agency
UNESCO International Hydrological Programme	The intergovernmental Hydrological Programme (IHP) is an intergovernmental programme of the United Nations system devoted to water research.	(Makarigakis & Jimenez-Cisneros, 2019)	Global	Agency
Food and Agriculture	The FAO employs specialists – described as neither scientists nor	(Soomai, 2017b)	Global	Expert Group

Organisation of the United Nations (FAO)	policy-makers – who 'translate' technical information for policymaking communities and other non-technical groups, such as the fisheries community and civil society, to engage them in policy networks.			
UNCCD Committee on Science and Technology (CST)	The CST is a subsidiary body to the United Nations Convention on Combatting Desertification which manages scientific input outside of the UNCCD Scientific Conference.	(Stringer & Dougill, 2013)	Global	Expert Group

Chapter 3

Appendix 3-1: Action Guide for SPI Legitimacy Analysis

For applying this action framework, this paper provides four practical steps designed to guide researchers, policymakers, and SPI practitioners in evaluating and enhancing the legitimacy of SPIs. This action guide aims to bridge the gap between theoretical concepts and practical implementation, offering a structured approach for both academic analysis and real-world application in the context of environmental governance and sustainability transformations.

1. *Define the scope for the SPI legitimacy analysis.*
   Begin by precisely delineating the scope of the SPI legitimacy assessment, clarifying whether the focus is on an individual SPI organization, one SPI network or an SPI output.

2. *Understand the SPI process from inputs to impacts.*
   Expand upon the understanding of the SPI process by clearly identifying the organizations of the SPI network and the power dynamics within the network. Furthermore, the respective outputs of the SPI need to be identified and how these outputs are expected to contribute to outcomes and subsequent impacts.

3. *Define the legitimacy criteria relevant to the SPI*
   In this step, legitimacy criteria relevant to the SPI need to be identified and possibly additional criteria not suggested in this action framework need to be added. Given that this step determines the outcome of the SPI legitimacy evaluation, it needs to be done very carefully, catering to the context and purpose of the evaluation. Because it is unlikely that all the perspectives can be covered by the same rigour and processes, transparency about the process design and underlying objectives is important. In this way SPIs can move from stealth issue advocacy created by the quest for effectiveness towards legitimation of power the SPIs use in environmental politics and governance.

4. *Evaluate the SPI*
   Following the operationalized action framework alongside the chosen criteria of legitimacy (*tables 5 to 7, exemplary operationalization questions*), the legitimacy of the SPI can be evaluated. This evaluation should not be seen as a one-shot effort, but as an iterative cyclical process where SPIs continuously seek to improve their legitimacy.

5. *Reflect and design for enhancing legitimacy*
   Building on the evaluation of SPI legitimacy, this provides a reflexive opportunity to further refine SPI processes and enhance their legitimacy. While it may be improbable to fully resolve contradictions and conflicts inherent in environmental politics, bolstering the legitimacy of SPIs can significantly contribute to advancing normative sustainability goals. Regular assessment of SPI legitimacy, for instance, utilizing the framework presented in this paper, could serve this critical purpose.

Chapter 4

Appendix 4-1: Interview List

Interview ID	Date	Interview Location	Research Country	Gender	Stakeholder Type[119]
1	07/02/2023	In-person	Ghana	Female	Policy
2	13/02/2023	In-person	Ghana	Female	University / Research Organisation
3	13/02/2023	In-person	Ghana	Female	University / Research Organisation
4	20/02/2023	Online	Ghana	Male	Policy
5	20/02/2023 and 22/02/2023	Online	Ghana	Male	University / Research Organisation
6.1	24/02/2023	In-person	Ghana	Male	Policy
6.2	24/02/3023	In-person	Ghana	Male	Policy
7	03/03/2023	Online	Ghana	Male	City Network
8	07/03/2023	In-person	Ghana	Male	Civil Society / Community
9	08/03/2023	Online	Ghana	Female	City Network
10	09/03/2023	In-person	Ghana	Male	Policy
11	13/03/2023	In-person	Ghana	Female	Civil Society / Community
12	15/03/2023	In-person	Ghana	Male	Policy
13	16/03/2023	In-person	Ghana	Female	Civil Society / Community
14	16/03/2023	In-person	Ghana	Male	Civil Society / Community
15	17/03/2023	In-person	Ghana	Female	Civil Society / Community
16	22/03/2023	online	Ghana	Male	University / Research Organisation
17	27/03/2023	online	Ghana	Female	Private Sector
18	27/03/2023	online	Ghana	Female	Private Sector
19	16/03/2023	In-person	Ghana	Male	Policy
20	15/03/2023	In-person	Ghana	Male	Civil Society / Community
21	27/03/2023	In-person	Ghana	Male	Policy
22	30/03/2023	In-person	Ghana	Male	Policy
23	30/03/2023	Online	Ghana	Male	University / Research Organisation
24	30/03/2023	In-person	Ghana	Male	University / Research Organisation
25	30/03/2023	In-person	Ghana	Male	University / Research Organisation
26	31/03/2023	In-person	Ghana	Male	Civil Society / Community
27	31/03/2023	In-person	Ghana	Male	City Network
28	06/07/2023	Online	Germany	Female	City Network
29	15/06/2023	Online	Germany	Male	Policy
30	19/06/2023	Online	Germany	Male	City Network
31.1	20/06/2023	Online	Germany	Female	Policy
31.2	20/06/2023	Online	Germany	Female	Policy

[119] The "Policy" category encompassed city government officials, elected representatives, and staff from relevant municipal departments such as environment, urban planning, and transportation. "University and Research Organisations" included academics, researchers, and representatives from think tanks who contributed expertise to the UCAP process. "Civil Society / Community" incorporated representatives from NGOs and advocacy groups, local residents and neighbourhood associations, "Private Sector" includes business representatives and consultants. Lastly, the "City Networks" category included representatives from national or international networks of cities focused on climate action, such as C40 Cities and ICLEI. The stakeholder types were assigned after the interviews were collected and it is acknowledged that there is possible overlap.

32		Online	Germany	Male	Civil Society / Community
33	28/06/2023	Online	Germany	Male	Policy
34	26/07/2023	Online	Germany	Male	City Network
35	26/07/2023	Online	Germany	Male	City Network
36	25/07/2023	Online	Germany	Male	Private Sector
37	15/08/2023	Online	Germany	Female	University / Research Organisation
38	20/07/2023	In-person	Brazil	Female	Policy
39	10/08/2023	In-person	Brazil	Male	Policy
40	31/08/2023	In-person	Brazil	Male	University / Research Organisation
41	15/08/2023	In-person	Brazil	Female	University / Research Organisation
42	17/08/2023	Online	Brazil	Female	University / Research Organisation
43	18/08/2023	Online	Brazil	Female	Policy
44	25/08/2023	Online	Brazil	Male	University / Research Organisation
45	26/08/2023	In-person	Brazil	Female	City Network
46	01/09/2023	In-person	Brazil	Female	University / Research Organisation
47		In-person	Brazil	Female	Policy
48	01/09/2023	In-person	Brazil	Female	City Network
49	04/09/2023	In-person	Brazil	Male	Civil Society / Community
50	05/09/2023	In-person	Brazil	Male	Civil Society / Community
51	08/09/2023	Online	Brazil	Male	Policy
52	13/08/2023	In-person	Brazil	Female	Policy
53	12/08/2023	In-person	Brazil	Male	Policy
54	25/09/2023	Online	Brazil	Male	Policy
55	07/10/2023	Online	Brazil	Male	City Network
56	26/09/2023	Online	Brazil	Male	University / Research Organisation
57	25/10/2023	In-person	India	Male	Policy
58	27/10/2023	In-person	India	Male	University / Research Organisation
59	31/10/2023	In-person	India	Female	Policy
60	06/11/2023	In-person	India	Male	Policy
61	06/11/2023	Online	India	Male	City Network
62	08/11/2023	In-person	India	Male	City Network
63	10/11/2023	Online	India	Male	City Network
64	24/11/2023	In-person	India	Male	Policy
65	26/11/2023	In-person	India	Male	Policy
66	26/11/2023	In-person	India	Male	Policy
67	29/11/2023	In-person	India	Male	Policy
68	01/12/2023	In-person	India	Male	Policy
69	01/12/2023	In-person	India	Male	Policy
70	06/12/2023	In-person	India	Female	City Network
71	28/11/2023	In-person	India	Male	Policy
72	07/12/2023	In-person	India	Female	Policy

Appendix 4-2: Interview Guide Chapter 4 – Legitimacy of UCAPs

Introduction
Hello! My name is Niklas Wagner, I am doctoral researcher at the Center for Development Research (ZEF) at the University of Bonn, conducting research on the creation process of the São Paulo Climate Action Plan („Plano Clima SP").

This interview is divided into several sections covering your role and involvement in the Plano Clima SP, the challenges and success factors of the creation process, the integration of diverse knowledge sources, stakeholder engagement, and the plan's impacts on climate mitigation, adaptation and sustainable development.

The insights you provide will contribute to an in-depth understanding of the Plano Clima SP development process and inform future efforts to strengthen the connection between knowledge and policy in addressing climate change and sustainable development in urban contexts. We appreciate you taking the time to share your experiences and perspectives.

The findings of this study will be published in our doctoral dissertations and academic journal articles. Please let me know if you have any other questions before we begin.

Informed Consent
Having signed the consent form with these options, I would simply go directly into the questions and start with Is it okay if we record, record and start.

A. **General Introduction**
　　1.　For which organization do you work?
　　2.　What role do you have in this organization?
　　3.　Do you work for more than one organization? If yes, please state the organizations you work for, your respective roles, and how these roles complement or contradict each other.

B. **Problem Statement and Interaction between Knowledge and Policy**
　　1.　Please state the three most significant mitigation and adaptation challenges with regards to climate change for São Paulo?
　　2.　What are the health hazards related to the impacts of climate change that, in your opinion, the urban population in São Paulo is exposed to.
　　3.　Do you believe that addressing these climate change-related challenges in São Paulo requires further information or knowledge? If yes, what are the main gaps? Please state up to three.
　　4.　In your opinion, to what extent does the collaboration between science and policy work in addressing the climate change-related challenges in São Paulo? Please rate from 1 to 5.

C. **Climate Action Plan (Plano Clima SP)**
　　1.　What is your role in the São Paulo Climate Action Plan („Plano Clima SP")?
　　　　i.　I am not aware of it.
　　　　ii.　I have heard about it.
　　　　iii.　I have read it.
　　　　iv.　I have contributed to it.
　　　　v.　I have authored parts of it.
　　2.　What role does the „Plano Clima SP" play according to you?
　　3.　How is the 'Plano Clima SP' integrated into other policies or plans of the city?
　　4.　What are the main enablers and barriers in the implementation of the plan?
　　5.　Please name at least five organizations with which your organization has collaborated most intensively in the development of the climate action plan. (Examples include city departments of São Paulo, government ministries, academic or private institutions, or transnational city networks)
　　6.　What was the role of C40 in this according to you?

D.   **SPI Process**
1.   How interdisciplinary do you consider the academic contributions to the „Plano Clima SP"? Please rate from 1 to 5 and explain which disciplines were involved.
2.   To what extent do you think the knowledge inputs (scientific and non-scientific) to the „Plano Clima SP" are valid and trustworthy? Please rate from 1 to 5 and explain your answer.
3.   To what extent did the „Plano Clima SP" process consider different forms of knowledge, such as local knowledge alongside scientific knowledge? Please explain which forms of knowledge were included and rate from 1 to 5.
    i.   Which other forms of knowledge were included?
4.   How inclusive did you find the „Plano Clima SP" process regarding stakeholders? Please rate from 1 to 5 and explain your answer.
    i.   Which stakeholders were excluded?
    ii.   What percentage of participants were women?
    iii.   What percentage of participants were youth (stakeholders under 30 years old)?
    iv.   What is the percentage of participants who had a disability?
5.   To what extent did political inputs into the „Plano Clima SP" process represent the interests of the citizens? Please rate from 1 to 5 and explain your answer.
6.   Do you believe that the ratio of knowledge inputs to political inputs in the „Plano Clima SP" process was adequate for the functionality of the plan? Please rate from 1 to 5 and explain your answer.
7.   How transparent do you consider the „Plano Clima SP" stakeholder selection process? Please rate from 1 to 5 and explain your answer.
8.   How transparent do you consider the process of creating the „Plano Clima SP"? Please rate from 1 to 5 and explain your answer.
9.   To what extent were power asymmetries between stakeholders considered in the „Plano Clima SP" process? Please rate from 1 to 5 and explain your answer.

E.   **SPI Results and Impacts**
1.   In your opinion, how accessible is the „Plano Clima SP"? Please rate from 1 to 5 and explain your answer.
2.   To what extent do you think the proposals of the „Plano Clima SP" are tailored to the needs and problems of the city? Please rate from 1 to 5 and explain your answer.
3.   To what extent do you consider the proposals of the „Plano Clima SP" to be financially feasible? Please rate from 1 to 5 and explain your answer.
    i.   To what extent does the „Plano Clima SP" help prioritize actions?
    ii.   Do you believe that the „Plano Clima SP" should place a stronger focus on setting priorities, considering the limited budget?
4.   To what extent is the implementation of the „Plano Clima SP" monitored?
5.   To what extent can „Plano Clima SP" stakeholders be held accountable for their contributions, or is there an accountability mechanism? Please rate from 1 to 5 and explain your answer.

F.   **SPI Impacts on Sustainability**
1.   In your opinion, what impacts does the „Plano Clima SP" have on climate mitigation? Please rate from 1 (negative impacts) to 5 (positive impacts) and explain your answer.
2.   In your opinion, what impacts does the „Plano Clima SP" have on climate adaptation? Please rate from 1 (negative impacts) to 5 (positive impacts) and explain your answer.
3.   In your opinion, what impacts does the „Plano Clima SP" have on poverty alleviation? Please rate from 1 (negative impacts) to 5 (positive impacts) and explain your answer (SDG 1).
4.   What impacts does the „Plano Clima SP" have on health and well-being, in your opinion? Please rate from 1 to 5 and explain your answer (SDG 3).
5.   What impacts does the „Plano Clima SP" have on gender equality, in your opinion? Please rate from 1 to 5 and explain your answer (SDG 5).

6. What impacts does the „Plano Clima SP" have on clean water and sanitation, in your opinion? Please rate from 1 to 5 and explain your answer (SDG 6).

7. What impacts does the „Plano Clima SP" have on reducing inequalities, in your opinion? Please rate from 1 to 5 and explain your answer (SDG 10).

8. What impacts does the „Plano Clima SP" have on the number of people affected by water-related disasters? Please rate from 1 to 5 and explain your answer (SDG 11.5).

9. What impacts does the „Plano Clima SP" have on „universal access to safe, inclusive, and accessible green and public spaces and systems for all"? Please rate from 1 to 5 and explain your answer (SDG 11.6).

10. What impacts does the „Plano Clima SP" have on reducing environmental pollution, in your opinion? Please rate from 1 to 5 and explain your answer (SDG 11.7).

11. What impacts does the „Plano Clima SP" have on protecting and restoring ecosystems and promoting sustainable use of resources, in your opinion? Please rate from 1 to 5 and explain your answer (SDG 15).

12. Is the 'Plano Clima SP' mainly driven by infrastructure measures, awareness measures or both?

G. **Assessment of the „Plano Clima SP" Process and Recommendations**

1. In your opinion, which aspects of the „Plano Clima SP" process were particularly successful? In your opinion, which aspects of the „Plano Clima SP" process were less successful or could be improved?

2. Do you have any other insights or comments about your experience with the „Plano Clima SP" and the SPI process?

3. What are other people who were involved in the plan we should try to speak to?

Thank you very much for your participation in this survey! Your answers will contribute to important insights about the „Plano Clima SP" process and the connection between knowledge and policy in the context of climate change.

Chapter 5

Appendix 5-1: Interview List Chapter 5

INTER-VIEW ID[120]	STAKE-HOLDER TYPE	WG[121]	LOCATION	GEN-DER	REGION	DURA-TION (MIN.)	DATE
2	UNFCCC[122]		UNFCCC COP26	M	GRULAC	62	1.11.21
3	UNFCCC		UNFCCC COP26	M	GRULAC		
4	IPCC	1	UNFCCC COP26	F	Asia	46	4.11.21
5	UNFCCC		UNFCCC COP26	M	Asia	38	6.11.21
6	UNFCCC		UNFCCC COP26	M	GRULAC	31	8.11.21
7	IPCC	1	UNFCCC COP26	F	WEOG	46	8.11.21
8	UNFCCC		UNFCCC COP26	M	WEOG	17	8.11.21
9	IPCC	1	UNFCCC COP26	M	WEOG	33	9.11.21
10	UNFCCC		UNFCCC COP26	F	WEOG	44	9.11.21
11	UNFCCC		UNFCCC COP26	F	WEOG	20	9.11.21
12	UNFCCC		UNFCCC COP26	F	GRULAC	22	9.11.21
13	IPCC	1	UNFCCC COP26	M	WEOG	27	9.11.21
14	UNFCCC		UNFCCC COP26	M	Asia	25	10.11.21
15	UNFCCC		UNFCCC COP26	F	GRULAC	32	10.11.21
16	UNFCCC		UNFCCC COP26	F	Africa	25	11.11.21
17	IPCC	2	UNFCCC COP26	M	WEOG	57	11.11.21
18	UNFCCC		UNFCCC COP26	M	WEOG	40	11.11.21
19	UNFCCC		UNFCCC COP26	F	GRULAC	26	11.11.21
20	IPCC	1	Zoom	F	GRULAC	38	13.12.21
21	IPCC	1	Zoom	M	WEOG	55	11.1.22
22	IPCC	1	Zoom	M	WEOG	51	13.1.22
36	IPCC	2	Zoom	M	WEOG	23	23.6.22
37	IPCC	2	SBSTA-56	M	Africa	31	07.6.22
38	UNFCCC		SBSTA-56	F	Africa	34	08.6.22
39	IPCC	3	SBSTA-56	F	WEOG	19	09.06.22

[120] Interview IDs not continuous as interviews were conducted together with research on complexity of collaboration between Rio Convention SPIs and interviews with IPBES and UNCCD SPI were deleted from the list.

[121] Working Group (WG)(if IPCC author)

[122] Interview with two interview partners

40	IPCC	3	SBSTA-56	M	WEOG	35	09.06.22
41	UNFCCC		SBSTA-56	F	Africa	35	11.06.22
42	IPCC	2	SBSTA-56	F	WEOG	25	13.06.22
43	UNFCCC		SBSTA-56	F	WEOG	16	15.06.22
44	UNFCCC		SBSTA-56	F	Asia	43	15.06.22
45	UNFCCC		SBSTA-56	M	GRULAC	21	16.06.22
46	IPCC	2	SBSTA-56	F	WEOG	30	16.06.22
47	IPCC	2	SBSTA-56	F	Asia	39	16.06.22
61	IPCC	3	UNFCCC COP27	M	WEOG	30	8.11.22
62	IPCC	2	UNFCCC COP27	F	GRULAC	11	10.11.22
63	IPCC	3	UNFCCC COP27	F	Africa	25	10.11.22
64	IPCC	2	UNFCCC COP27	M	GRULAC	40	12.11.22
65	IPCC	2	UNFCCC COP27	F	Asia	29	15.11.22
66	UNFCCC		UNFCCC COP27	F	Asia	25	15.11.22
67	IPCC	2	UNFCCC COP27	F	Asia	37	25.11.22
68	IPCC	2	UNFCCC COP27	M	Africa	38	22.11.22
69	IPCC	2	UNFCCC COP27	F	WEOG	35	12.12.22
70	IPCC	3	UNFCCC COP27	F	WEOG	33	16.12.22
71	IPCC	2	UNFCCC COP27	F	Asia	16	18.11.22
72	IPCC	3	UNFCCC COP27	M	WEOG	58	20.11.22

Appendix 5-2: Interview Guide Chapter 5, IPCC

Introduction (use as 1-pager)

- Hello! We are Sara Velander and Niklas Wagner and we are working as doctoral researchers at the Center for Development Research (ZEF) at the University of Bonn.
- The interview is divided into 3-4 different topics, asking you about your role as a stakeholder in COP26, relation to the IPCC, your experiences and views of the processes and outcomes of SPIs related to the institutional design, trust, representation of diverse knowledge systems, the integration of other SDG topics in SPI products, factors in knowledge transfer, as well as collaboration between SPIs.
- This knowledge will inform the literature as well as SPI leadership on the challenges SPIs face and ways to improve their effectiveness in providing decisionmakers with the best, available information on pressing societal problems, such as, climate change.
- The findings of this study will be published in our doctoral dissertations and journal articles

Informed Consent
Having signed the consent form with these options, I would simply go directly into the questions and start with Is it okay if we record, record and start.

SPI Stakeholder
1. What is your gender?
2. What country are you from?
3. What is your role at the COP?

SPI Legitimacy
4. How comprehensible is the information in IPCC reports?
5. What is the role of the IPCC reports for the negotiations in the UNFCCC COP?
6. How authoritative are the IPCC reports for decision-making at the COP? Please rate from 1 (lowest) to 5 (highest).
7. To what extent has the authority of the IPCC report changed over time? Choose a response option, give examples and explain.
8. How much do you trust the IPCC findings? Please rate from 1 to 5. Explain your answer.
9. Does your trust in the IPCC come more from the trust in science in general or from the institutional reputation of the IPCC? Please explain your answer.
10. How transparent is the IPCC process? Please rate from 1 to 5
11. Do you think the IPCC reports fairly represent the current state of knowledge? Please rate from 1 to 5.
12. What relevant sources of knowledge and perspectives do you think are underrepresented in the IPCC reports?
13. ASK 12 and 13 together: To what extent do you think the IPCC report is subject to political influence? Please rate from 1 to 5.
14. If so, what players do you think have the most influence on decision-making within the IPCC and in what way?
15. What are your desired outcomes of the COP?
16. What would you change about the IPCC's institutional design in order to increase its effectiveness?

Last question: Do you know anyone else who may be interested in participating in our research?

Conclusion

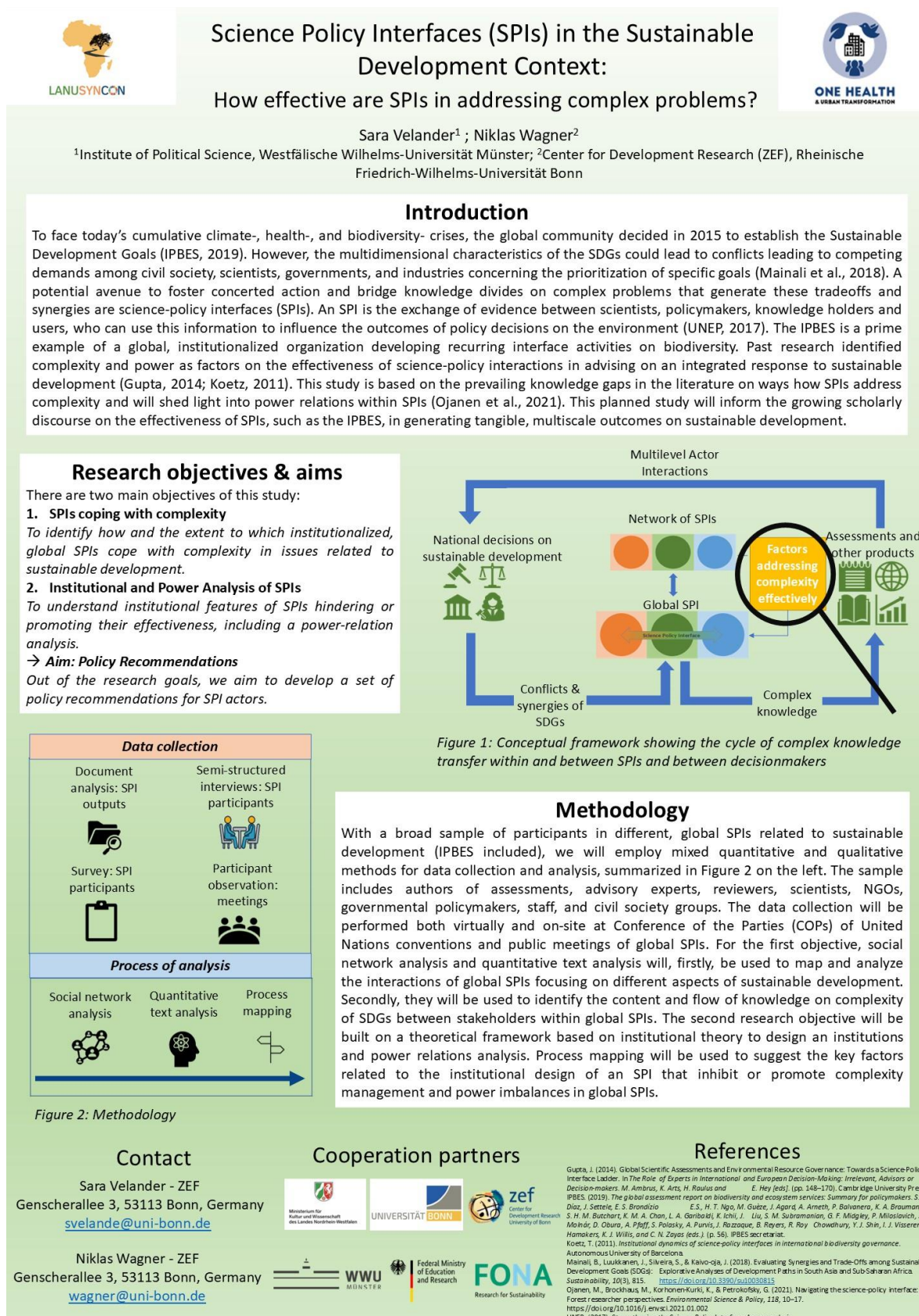## Appendix C-1: Poster IPBES Stakeholder Days

Science Policy Interfaces (SPIs) in the Sustainable Development Context:
How effective are SPIs in addressing complex problems?

Sara Velander[1] ; Niklas Wagner[2]
[1]Institute of Political Science, Westfälische Wilhelms-Universität Münster; [2]Center for Development Research (ZEF), Rheinische Friedrich-Wilhelms-Universität Bonn

Introduction

To face today's cumulative climate-, health-, and biodiversity- crises, the global community decided in 2015 to establish the Sustainable Development Goals (IPBES, 2019). However, the multidimensional characteristics of the SDGs could lead to conflicts leading to competing demands among civil society, scientists, governments, and industries concerning the prioritization of specific goals (Mainali et al., 2018). A potential avenue to foster concerted action and bridge knowledge divides on complex problems that generate these tradeoffs and synergies are science-policy interfaces (SPIs). An SPI is the exchange of evidence between scientists, policymakers, knowledge holders and users, who can use this information to influence the outcomes of policy decisions on the environment (UNEP, 2017). The IPBES is a prime example of a global, institutionalized organization developing recurring interface activities on biodiversity. Past research identified complexity and power as factors on the effectiveness of science-policy interactions in advising on an integrated response to sustainable development (Gupta, 2014; Koetz, 2011). This study is based on the prevailing knowledge gaps in the literature on ways how SPIs address complexity and will shed light into power relations within SPIs (Ojanen et al., 2021). This planned study will inform the growing scholarly discourse on the effectiveness of SPIs, such as the IPBES, in generating tangible, multiscale outcomes on sustainable development.

Research objectives & aims

There are two main objectives of this study:
1. **SPIs coping with complexity**
To identify how and the extent to which institutionalized, global SPIs cope with complexity in issues related to sustainable development.
2. **Institutional and Power Analysis of SPIs**
To understand institutional features of SPIs hindering or promoting their effectiveness, including a power-relation analysis.
→ *Aim: Policy Recommendations*
Out of the research goals, we aim to develop a set of policy recommendations for SPI actors.

Multilevel Actor Interactions

Figure 1: Conceptual framework showing the cycle of complex knowledge transfer within and between SPIs and between decisionmakers

Data collection

Document analysis: SPI outputs

Semi-structured interviews: SPI participants

Survey: SPI participants

Participant observation: meetings

Process of analysis

Social network analysis

Quantitative text analysis

Process mapping

Figure 2: Methodology

Methodology

With a broad sample of participants in different, global SPIs related to sustainable development (IPBES included), we will employ mixed quantitative and qualitative methods for data collection and analysis, summarized in Figure 2 on the left. The sample includes authors of assessments, advisory experts, reviewers, scientists, NGOs, governmental policymakers, staff, and civil society groups. The data collection will be performed both virtually and on-site at Conference of the Parties (COPs) of United Nations conventions and public meetings of global SPIs. For the first objective, social network analysis and quantitative text analysis will, firstly, be used to map and analyze the interactions of global SPIs focusing on different aspects of sustainable development. Secondly, they will be used to identify the content and flow of knowledge on complexity of SDGs between stakeholders within global SPIs. The second research objective will be built on a theoretical framework based on institutional theory to design an institutions and power relations analysis. Process mapping will be used to suggest the key factors related to the institutional design of an SPI that inhibit or promote complexity management and power imbalances in global SPIs.

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Cooperation partners

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Ojanen, M., Brockhaus, M., Korhonen-Kurki, K., & Petrokofsky, G. (2021). Navigating the science-policy interface: Forest researcher perspectives. *Environmental Science & Policy, 118, 10–17.* https://doi.org/10.1016/j.envsci.2021.01.002
UNEP. (2017). *Strengthening the Science-Policy Interface: A gap analysis.*

Figure 15: Poster IPBES Stakeholder Day

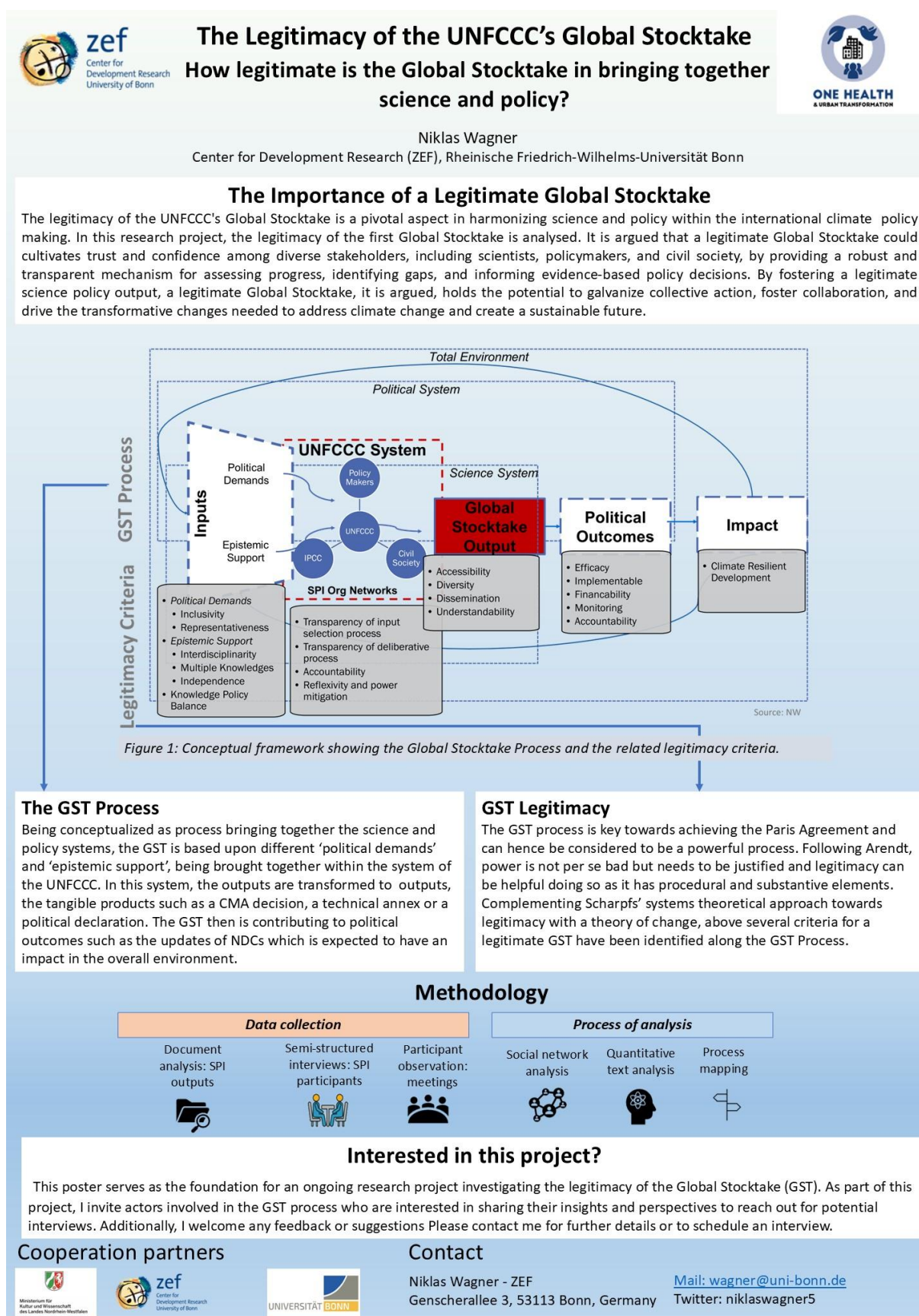## Appendix C-2: Poster on a Legitimate UNFCCC Global Stocktake

Figure 16: Poster legitimate GST SB58

Appendix C-3: Exemplary Blog Post on ICLEI Conference

The Importance of Knowledge Platforms for Sustainable Cities

Reflections and impressions from the ICLEI World Conference in Malmö, Sweden, in May 2022.

By Niklas Wagner, junior researcher at the One Health and Urban Transformation Graduate School of ZEF/ University of Bonn. Niklas's research focuses on institutions that connect knowledge and policy in the context of urban climate resilience. He participated in the World Congress of Local Governments for Sustainability ICLEIthat was jointly held with the 6th ICLEI Research Symposium in 2021/22 in mid-May in Malmö, Sweden. Subsequently, Niklas joined the First Regional Convening of the Intergovernmental Panel on Climate Change (IPCC) for the Summary Urban Policy Makers Process (SUP). He shares his insights in this blog post.

The importance of cities and ICLEI as a transnational network of cities

Cities are playing a pivotal role in addressing the climate crisis: Whereas the majority of the world's population is currently living in cities, United Nations Habitat expects more than 70% to be living in urban areas by 2050. More than 70% of the world's greenhouse gas emissions are generated by cities. Therefore, cities will be key in addressing the urgently needed reduction of greenhouse gas emissions by mitigation measures. While being responsible for the majority of the world's emissions, city dwellers are still among the most vulnerable when it comes to coping with the devastating impacts of climate change. The IPCC warns in its most recent report (2022) that especially the poorest on the globe are suffering and will

suffer even more from the effects of floods, storms, extreme heatwaves, as well as sea-level rise. Thus, cities are key actors in both mitigation and adaptation measures to counter the impacts of climate change.

For connecting these key actors, transnational sustainability networks of cities have become more important. One of these networks is ICLEI (Local Governments for Sustainability), with more than 1750 member cities in more than 126 countries. ICLEI'S mission is to build and serve a worldwide movement of local governments to achieve tangible improvements in global sustainability. To achieve its mission, ICLEI has included an advocacy and knowledge-generating role in promoting sustainability in its mandate.

Figure 17: Night-train Snälltaget

"As a researcher, I look into the legitimacy of organizations connecting knowledge and policy in the urban climate- resilience context".

So I decided to participate in the ICLEI World Congress and the 6th ICLEI Research Symposium 2021/2022 taking place in the city of Malmö, Sweden, in mid-May this year to get some more insights. My trip to the conference began with a train ride to Hamburg on the evening of May 9, my first travel per night train in mainland Europe! The Swedish train company *snälltaeget* started operating between Berlin and Stockholm only

last year, so I was excited to travel on this route from Hamburg to Malmö. After around seven hours of sleep, I woke up with the sun rising above the (Strait of) Oresund between Copenhagen and Malmö. I arrived in Malmö just in time to leave my luggage at the Airbnb and join the first part of the conference, starting at 9 am, which was a Research Symposium hosted by the United Nations Maritime University.

The ICLEI Research Symposium

As my research covers organizations bringing together knowledge-holders and policymakers, ICLEI's research symposium, bringing together researchers and city leaders, was of special interest to me. I was interested to see how and what ICLEI would do and achieve in this regard. The stated objectives of the research symposium were to bring together researchers with city leaders, to co-create approaches to create actionable knowledge as well as to stimulate discussions on how relevant knowledge gaps could be addressed.

Directly at the start of the symposium knowledge gaps in the field of urban climate resilience were presented as part of the (GRAA) for cities and climate change, which was launched here. The GRAA is a cornerstone of a special report on cities and climate change to be produced by the Intergovernmental Panel on Climate Change IPCC during its seventh assessment cycle. This special IPCC report was proposed by the government of South Africa in 2018 and is now stimulating new research through the GRAA. In my opinion, this interaction of how politics can stimulate relevant research is a fascinating example of how science and policy are interwoven.

By promoting the implementation of the GRAA and presenting its own research agenda at the Research Symposium it became clear to me that ICLEI wants to position itself as a leader in the realm of policy-practice interface. I learned about ICLEI's role later during the main conference as well, but this statement on its own was interesting for my

research as it shows how ICLEI actively intends to build a platform for connecting knowledge and policy.

The Research Symposium also showed how ICLEI is already serving as a knowledge platform that is bringing together policymakers and knowledge holders. The Research Market Place with its power-pitches brought together different stakeholders and generated interesting discussions around planned research. However, one day was simply too short to co-create approaches for creating actionable knowledge. But I hope that a lasting cooperation has been formed during these days.

Figure 18: Niklas Wagner presenting at the research market Place at ICLEI's 6th Research Symposium

First Regional Convening of the IPCC Summary for Urban Policy Makers Process

At the side of the ICLEI conference, the first regional convening of the so-called IPCC Summary for Urban Policy Makers Project took place. This convening brings together mayors and their climate specialists with IPCC authors to produce a summary of the three latest IPCC reports published in the sixth assessment cycle. The summary covers the physical science base of climate change, the impacts, and adaptation as well as mitigation options relevant for urban policymakers. I took part in the regional convening of European countries in the city hall in Malmö, where I was able to observe this meeting from a researcher's perspective. It was interesting to see how policymakers

were interacting with the IPCC authors, highlighting the usefulness of this information sharing. Right from the first meeting's start, it was made clear that language clarity and simplicity are absolutely crucial for the interaction between policymakers and scientists. I am grateful to continue to follow this process in future as it seems to be a light-house example of how IPCC knowledge could become actionable.

Figure 19: Participants of the first regional convening of the IPCC SUP Process

The ICLEI World Congress

The observation I made at the Research Symposium that ICLEI connects knowledge and policy was endorsed in a, for me unexpected, but interesting way.

> „*Actually, the whole conference was designed to build networks, networks, networks…* „

During the event's launch, for example, the audience was seated around round tables and encouraged to sit with people they did not know yet. Thus, discussions could be generated and new network options explored. Next to round tables during the sessions, there were a lot and extensive networking options and opportunities during coffee, lunch, and dinner breaks – created by design. This might not come as a surprise for frequent conference participants. For me as a researcher on interfaces between knowledge and policy, it was still interesting, though. Next to more science- and research-based knowledge exchange, networking was used to exchange implementation-oriented knowledge between policymakers during

social interaction. This part of in-person social interaction was crucial, especially after more than two years of pandemic dominated by virtual-exchange.

Thematically, the conference centered on urban sustainability topics. Issues like the importance of urban blue and green spaces for urban biodiversity, how planetary health can be achieved in cities, and how data play a role in implementing climate-mitigation measures were addressed theme-wise. Personally interesting to me was a session on science-based targets allocating a certain carbon budget to cities from which they derive a climate-mitigation goal. This was highly interesting because the session was a prime example for me of how facts and values intersect as various justice considerations have to be taken into consideration (historic emissions, capacity to mitigate, consequences for those not involved in the decision) when these science-based targets are defined. Overall, many of the sessions underlined how important a just and equitable transition is for achieving urban sustainability.

Figure 20: Youth Participation at the closing ceremony of the conference.

Figure 21: Niklas (right) with the Mayors of Bonn and Freiburg, Katja Dörner and Martin Horn

It has to be emphasized that in order to achieve a just and equitable transition, procedure-wise all relevant stakeholders have to be included in the exchange of knowledge. Here, the lack of inclusiveness must be mentioned: With conference fees ranging from roughly 500 to 1,000 Euros for 4 days excluding accommodation and travel, only a very limited subset of cities and researchers have been able to attend this conference. While I am aware of the fact that ICLEI is a network funded mainly by its membership fees, more equitable access should be top of the list of discussions revolving around just, inclusive, and equitable transitions. In contrast to the excluded voices, the voices of sponsoring businesses could be heard quite loudly and clearly in the discussions at the conference. This must be taken into account when evaluating ICLEI's ability as a global knowledge platform.

"To conclude my blog post I'd like to say that this conference visit offered me very interesting perspectives on the knowledge role of one of the most important transnational city networks in the context of sustainability. However, there is much room left for future research! Looking forward to it". Niklas Wagner, ZEF junior researcher

Appendix C-4: Exemplary LinkedIn Posts about IPBES 9 Plenary

Figure 22: Linked-In post IPBES plenary 2022

Appendix C-5: Reflection Piece by Sara Velander

Sara Velander is a junior researcher and doctoral candidate in the LANUSYNCON project at the Centre for Development Research working on the complexity of SPI collaborations. Together with our joint supervisor Thomas Dietz, we planned to align our work from the very beginning and worked especially closely together in the initial stages of the PhD journey. Next to collaborating on the publication included as Chapter 2 here, we have worked on posters, chapters, master thesis supervisions and interviews together.

Niklas Wagner and I collaborated closely throughout our PhD journey, driven by a shared focus on science-policy interfaces (SPIs) within environmental sustainability. Over the past three to four years, he consistently challenged my perspectives, enriching our joint exploration of effectiveness, legitimacy, and the complex dynamics of expertise in global environmental governance.

Niklas encouraged me to approach science-policy processes with a critical and philosophical lens, especially concerning the role of knowledge in decision-making. He cautioned against over-empowering scientists, particularly those from the Global North who represent 'Western science' and instead emphasized the need for balanced, inclusive expertise.

His guidance broadened my understanding of science-policy processes, inspiring me to adopt a macro-level approach and use conceptual diagrams to clarify cognitive model differences. He was also instrumental in sourcing pivotal literature, especially works highlighting the injustices in global science-policy processes and the importance of integrating diverse knowledge systems - such as those from Indigenous peoples and local communities - to address complex, interconnected issues.

For instance, in one of my recent papers on the collaboration between SPIs to cope with complexity, Niklas underscored the necessity of inclusive co-production within SPI-related organizations for effective collaboration between these organizations. As a result, I incorporated this concept as a dimension in the conceptual framework of my paper. This addition helped bridge literature on institutional complexity and SPI co-production.

These are just a few of the many invaluable insights Niklas shared, including his encouragement to be more mindful of our carbon footprint as researchers frequently traveling by air to academic conferences. He also highlighted the privilege inherent in having access to alternative, more sustainable modes of transport.

Overall, Niklas' contributions have profoundly shaped my research journey. I am deeply grateful for our rich discussions and collaborations, from co-authoring research papers and organizing a conference panel to conducting interviews with IPCC and IPBES scientists at UN climate and biodiversity conferences, and more recently, co-authoring a chapter together.

Appendix C-6: Reflection Piece by Shaurya Patel

Shaurya Patel is a research fellow at the Global Centre for Energy and Environment of Ahmedabad University where I stayed from October to December 2023. We are both working under the UNFCCC's youth constituency YOUNGO and are currently collaborating on a paper analysing the inclusivity of the IPCC's special report on cities.

Interactions, Intersection, and Inter-understanding

Reflecting on my experience with the science-policy interface (SPI), my foundational knowledge came primarily from working with the Co-Chair and Technical Support Unit (TSU) of Working Group III during the IPCC's Assessment Report Six (AR6) cycle. This journey lasted until 2023, when you (Niklas) reached out with an interest in studying Ahmedabad, my city. The curiosity you brought as someone new to this environment prompted me to think deeply about how external and internal perspectives might differently illuminate urban challenges and opportunities. It made me wonder: could my „lived experience" provide a unique lens, or would an external viewpoint yield insights that even I might overlook? I was intrigued by the application of SPI in a city-focused context, an approach I hadn't previously considered. Before our discussions, my view of SPI was largely anchored in broader contexts based on the IPCC approach, however seeing it applied at the city level opened my mind to the potential of SPI as an interaction and intersection space that cultivates new forms of understanding. This dialogue also paralleled with my ongoing master's studies in International Relations, where I explored political science perspectives and IR theories. Your approach helped reshape my perception of SPI, extending it from urban planning to encompass both localized and international systems. As someone grounded in urban planning and now exploring IR, I am grateful for how our discussions expanded my grasp of SPI's scale and applicability. This experience has reinforced my interest in both theoretical and evidence-based approaches, especially given the increasing demand for SPI in India from city-level governance to international relations. I doubt I would have gained this insight without our collaborative exchanges, and I'm inspired to consider SPI as a potential focus in my future PhD pursuits.

Appendix C-7: Reflection Piece by Eric Sebastian Kalversberg

Eric Sebastian Kalversberg was my research assistant from April 2023 to February 2024, did his Bachelor Thesis titled on the knowledge role of city networks under my supervision, partially based. Currently we are working on a paper adding an epistemic dimension to Gaventa (2006) Power Cube.

In today's academic world, with its publish or perish culture and strict dissertation deadlines, there is little room for „mistakes". However, what I have come to particularly value is your ability to consistently and radically question and adapt your research approaches.

While closely following and contributing to your research journey, I could observe how your perspective gradually shifted by almost 180°, from focusing on how science can better be linked to policy in addressing

socio-ecological issues, towards recognizing how modernist Eurocentric science itself is complicit in hindering social-ecological transformations and causing epistemological harm.

This shift was eye-opening and highlighted the often unpredictable trajectories that research can, and perhaps should, take. Your ability to continuously question your own research and, when necessary, start from o different point of inquiry, showed me that this is a sign of courage, rather than a mistake.

By making the world of science, which I initially approached with great respect, awe, and a certain hesitancy, more approachable, you fuelled my interest in research. You encouraged me to engage more deeply with scientific discourse and significantly shaped the ambitions behind my bachelor's thesis, which benefited greatly from our discussions and your guidance, as well as much beyond that.

Thank you, Niklas, for these invaluable insights and for your trust in my contributions. I look forward to many more thought-provoking discussions.

Appendix C-8: Reflection Piece by Bjarne Behrens

Bjarne Behrens is a fellow climate activist I worked with at the international climate level as well as in the open surface coal mining occupation 'Lützerath'.

Since I know Niklas, he is a passionate scientist and climate activist. Most people I know at some point in their lives prioritize one over the other. But not Niklas, somehow, he manages at any point in his life to combine both. With his research on the IPCC, he has found a way to build bridges between climate activists and scientists and to politicise the latter. At the same time, he has used his privileged access as a researcher to knowledge and events such as the COPs sensibly in the interest of the climate movement. Besides all the difficulties, he has so far never lost his political compass and his high motivation. If he should one day come to the point where he has to choose between his career and social engagement, I hope he knows which side to take.

Appendix C-9: Reflection Piece by Shreya K.C.

Shreya K.C. was the coordinator of the YOUNGO working group on the Global Stocktake (GST) at the international climate level UNFCCC, where I was engaged as a member of Klimadelegation e.V.

My name is Shreya K.C. from Nepal. I first met Niklas in 2022 during the 56th session of the Subsidiary Body conference in Bonn in a cross-constituency coordination meeting on GST. He was a member of CAN International and expressed interest in engaging with the YOUNGO NDCs Working Group, which I was coordinating.

Since then, he has become an integral part of the team, taking and sharing notes with others, actively following the GST discussions at subsequent conferences such as COP27, SB58, COP28 and beyond. He consistently made an effort to engage other youth activists and members in GST processes by debriefing them on ongoing GST discussions and synergizing efforts across different initiatives of YOUNGO. His

dedication, hard work, kindness and knowledge have deeply influenced our work in GST, particularly in fostering team work, collaboration and intergenerational principles in GST discussions and outcomes.

His poster session at SB60 provided us with a strong understanding of the importance of legitimacy in the GST process and why it should deliver trust and hope in multilateralism and climate action. I also had the opportunity to give two interviews for his study on the GST process at SB58 and reflecting on the outcomes and subsequent discussions during COP29.

I am truly grateful for his active contribution and passion to make a difference. I wish him all the best in his further academic and professional endeavors, including his PhD.

Appendix C-10: Reflection Piece by Ana Maria Perez Arredondo

Ana Maria Perez Arredondo was part of the previous batch of students of the 'One Health and Urban Transformation Graduate School' and became coordinator of the research project.

I met Niklas in the context of the One Health Graduate School. The first meeting was remote, in early 2021, as many people had to work from home due to sanitary restrictions. I don't remember much of that meeting, except that I invited all of the new students to visit me home for coffee and cake, and Niklas was the only one who actually came. I was very happy with his short visit.

Not much time later, I took over the coordination of the Graduate School, meaning that I had to get familiar with the work of the students, support them, and make sure that their research topics were aligned with the overarching goal of the program, and with Niklas I had the feeling that from time to time I had to make an extra effort.

In the institute where we work, we all develop an intuition about transdisciplinary research, but it was the contact with Niklas, his project, and all those extra efforts from my side to under how he was fitting in the program, that made me aware of different theories and approaches to knowledge evolution, co-creation, and application, which is very valuable for me.

On a personal level, I am amazed by his inner drive and engagement with climate activism. In a way, his critical and pragmatic views to existing paradigms have influenced my own way of perception. Although at the beginning it was hard for me to understand some of his reasoning.

Very quickly I learned to appreciate Niklas as colleague and friend, and I don't want to leave unmentioned that we had very good conversations about Mexico and the Mexican food, which I believe was bringing a warm feeling to both of us.

Creative Finish: Letter for A Future Child

German Translation below[123]

My Dear Potential Son, My Dear Potential Daughter,

As I sit on a minibus between Baku and Tbilisi on my way back from the 29th World Climate Conference - tired and exhausted, but also disappointed and deeply worried - I think about the world we are leaving to you: Will you still be able to experience the beauty of nature, rivers, and forests as I and my friends did? Will we be able to play in the snow together? Will you still be able to enjoy your summers joyfully despite the steadily rising temperatures?

Or will entirely different worries occupy your mind - worries that may not yet fully dawn on me, perhaps due to a mix of naivety, denial, and optimism? As I wrote my doctoral thesis, just 100 kilometres from Bonn in the Ahr Valley, hundreds of people lost their lives and homes to floods caused by extreme rainfall. Meanwhile, thousands die prematurely every year in Germany alone due to heatwaves. And worldwide, in a world where wealth is distributed with profound injustice, the situation in most regions is even more catastrophic.

In light of this reality, I ask myself how I would respond if, one day, you were to ask me: „*What did you do to leave me, within your means, a liveable planet? How did you fulfil the responsibility that comes with your privileges? What did you do for climate justice?*"

At first, I might answer you with a touch of pride, recounting how I adapted my lifestyle early on to contribute, at an individual level, to a liveable planet for you. I would tell you about my activism in the climate justice movement, where I worked to change structures, and how I increasingly linked this work to my research during my doctoral studies, striving to make a positive impact through science.

Yet, in a second moment, doubt would creep in: Was it enough? Was it good enough? By engaging with the UN, did I unwittingly support institutions that, for over 30 years, have failed to produce solutions commensurate with the urgency of the crisis? Was it right to invest so much time and energy in a doctoral thesis during an acute crisis? Does my work in academia reinforce a system that often reproduces or even amplifies injustice instead of eliminating it?

Then, in a third moment, I would tell you that I have continually questioned my role. I did not act lightly but tried my best to ensure my decisions were right in their respective moments. I am part of a society whose systems and structures were not designed for the climate crisis but have shaped and influenced me. I believed there isn't a single „correct" role to play in transforming these structures toward a more liveable planet. And that despite all my doubts, I never buried my head in the sand - because the urgency of the crisis simply didn't allow for that.

I know that, from your perspective, much of what I did may not seem right, and some of my decisions may be incomprehensible or even unforgivable. But I hope you see in my actions and words that I tried. That I tried not just to leave footprints on this planet but to sow seeds - seeds for a fairer, more loving, and resilient world where your children, too, can one day play and dream.

With love,

Your (Future) Father

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[123] Translated with the AI tool "ChatGPT".

Mein lieber potentieller Sohn, meine liebe potentielle Tochter!

Während ich in einem Kleinbus zwischen Baku und Tiflis auf dem Rückweg von der 29. Weltklimakonferenz sitze – müde und erschöpft, aber auch enttäuscht und voller Sorge –, denke ich an die Welt, wie wir sie Dir hinterlassen werden: Wirst Du noch die Schönheit der Natur, der Flüsse und Wälder so erleben dürfen wie ich und meine Freunde? Werden wir gemeinsam im Schnee spielen können? Wirst Du Deine Sommer trotz stetig steigender Temperaturen noch freudig genießen können?

Oder werden es ganz andere Sorgen sein, die Dich beschäftigen – Sorgen, die mir vielleicht aufgrund einer Mischung aus Blauäugigkeit, Verdrängung und Optimismus, momentan gar nicht dauerhaft präsent sind? Denn während ich meine Doktorarbeit schrieb, sind keine 100 Kilometer von Bonn entfernt im Ahrtal hunderte Menschen in Fluten infolge von Extremregen gestorben und haben ihr Zuhause verloren. Gleichzeitig sterben allein in Deutschland jedes Jahr tausende Menschen frühzeitig aufgrund der Hitze. Und weltweit, in einer Welt mit zutiefst ungerecht verteiltem Wohlstand, sieht die Lage in den meisten Regionen noch deutlich verheerender aus.

Im Angesicht dieser Realität frage ich mich, wie ich Dir antworten würde, wenn Du mich eines Tages fragst: *„Was hast Du getan, um mir, im Rahmen des Möglichen, einen lebenswerten Planeten zu hinterlassen? Inwiefern wurdest Du der Verantwortung gerecht, die aus Deinen Privilegien erwächst? Was hast Du für Klimagerechtigkeit getan?"*

In einem ersten Moment würde ich Dir vermutlich sogar mit ein bisschen Stolz erzählen, wie ich schon in frühen Jahren meinen Lebensstil angepasst habe, um auf individueller Ebene zu einem lebenswerten Planeten beizutragen. Ich würde von meinem Engagement in der Klimagerechtigkeitsbewegung berichten, wo ich versucht habe, Strukturen zu verändern, und davon, wie ich diese Arbeit im Laufe meiner Promotion immer enger mit meiner Forschung verbunden habe, um auch durch meine wissenschaftliche Tätigkeit einen positiven Beitrag zu leisten.

In einem zweiten Moment würden mir jedoch meine Zweifel kommen: War das genug? War es gut genug? Habe ich durch mein Engagement auf UN-Ebene nicht auch Institutionen gestützt, die seit mehr als 30 Jahren keine Lösungen hervorgebracht haben, die der Dringlichkeit der Krise gerecht werden? War es richtig, in einer akuten Krise so viel Zeit und Energie in eine Doktorarbeit zu investieren? Stütze ich mit meiner Tätigkeit in der Wissenschaft nicht ein System, das Ungerechtigkeit oft mehr reproduziert oder verstärkt, anstatt sie zu beseitigen?

Und dann, in einem dritten Moment, würde ich Dir sagen, dass ich meine Rolle immer wieder hinterfragt habe. Dass ich nicht leichtfertig gehandelt habe, sondern mein Bestes gegeben habe, um sicherzustellen, dass meine Entscheidungen im jeweiligen Moment die richtigen waren. Dass ich Teil einer Gesellschaft bin, deren Systeme und Strukturen nicht für die Klimakrise gemacht waren, die mich aber geprägt und geformt haben. Dass ich überzeugt war, dass es nicht die eine richtige Rolle gibt, um diese Strukturen hin zu einem lebenswerteren Planeten zu verändern. Und dass ich trotz aller Zweifel nie den Kopf in den Sand gesteckt habe – weil die Dringlichkeit der Krise das einfach nicht zugelassen hat.

Ich weiß, dass vieles aus Deiner Perspektive nicht richtig erscheinen mag und manche meiner Entscheidungen nicht nachvollziebar geschweigedenn entschuldbar sein werden. Aber ich hoffe, dass Du in meinem Handeln und meinen Worten erkennst, dass ich es versucht habe. Dass ich versucht habe, nicht nur Spuren auf diesem Planeten, sondern Samen zu hinterlassen – Samen für eine gerechtere, liebevollere und resilientere Welt, in der auch Deine Kinder eines Tages spielen und träumen können.

In Liebe,

Dein (zukünftiger) Vater