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MSc. Thesis

Ex-ante Measurement of Procedural Justice in Climate Change Adaptation

APPLICATION OF THE INSTITUTIONAL ANALYSIS APPROACH TO
ASSESSING ALIGNMENT WITH CLIMATE JUSTICE

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Cover Image: A network of policy statements formed from the Disaster Management plan of

Executive Summary

This thesis explores the critical intersection of climate change adaptation and procedural justice. As vulnerable communities face escalating climate change impacts, ensuring their just and inclusive adaptation is a pressing challenge. Procedural justice, which focuses on the fairness of decision-making processes from a systemic perspective, remains underexplored in climate adaptation research and practice.

The thesis aims to develop an approach for evaluating the procedural justice of climate change adaptation policies ex-ante, before their implementation. Applying the Institutional Analysis and Development (IAD) framework, the research examines how formal rules within policy environments influence the facilitation or impediment of procedural justice principles.

A case study of a World Bank-funded wastewater infrastructure project in Chennai, India provides the empirical context. The methodology involves two key components:

- 1) An automated tool leveraging Large Language Models (LLMs) to identify and annotate institutional statements from relevant policy documents
- 2) A structured analysis of the resulting institutionally coded statements to assess their alignment with principles of voice, transparency, accountability and correctability.

The thesis makes methodological and theoretical contributions. It pioneers the application of LLMs to partially automate the labour-intensive process of coding voluminous policy documents with the Institutional Grammar syntax. It also operationalizes and refines procedural justice principles for ex-ante institutional analysis in a novel domain.

Key findings indicate that the current institutional environment inadequately addresses procedural justice considerations across the planning, construction and operation phases of wastewater projects. The research highlights the need for explicit rules to ensure meaningful participation, information disclosure, accountability and corrective mechanisms. In Chapter 4, I identify 4 values of procedural justice, namely Voice, Transparency, Accountability and Correctability, which contribute to fairness in institutions. I operationalise these values as institutional structures using the Institutional Analysis and Development framework, through the development of institutional network diagrams. This analytical framework becomes the backbone of the subsequent empirical evaluation.

In Chapter 5 I show that the application of Large Language Models (LLMs) to the automated annotation of institutional statements was effective in reducing the labour-intensive nature of

the Institutional Grammar (IG) coding process. The LLM-based system demonstrated an overall accuracy of 0.6 in identifying and tagging institutional statements within policy documents, significantly improving over the state-of-the-art in the efficiency and scalability of the analysis. The experiment showed that the system could reliably handle complex sentence structures and multiple institutional statements, making it a valuable tool for policy analysis in large-scale projects.

In Chapter 6, the analysis of procedural justice in the selected case study highlighted several critical gaps in the current institutional environment. The descriptive coding of policy documents revealed that the existing institutional rules inadequately addressed procedural justice considerations across the planning, construction, and operation phases of the wastewater project. Specifically, there were deficiencies in ensuring meaningful participation, transparency, and accountability, particularly for vulnerable groups affected by the project. The comparison with the World Bank's assessment further underscored these gaps, suggesting a need for more explicit rules and guidelines to promote procedural fairness in climate adaptation projects.

Chapter 7 synthesizes the broader implications of these findings, emphasizing the importance of integrating procedural justice into climate adaptation policies. The research concludes that while the current institutional frameworks provide some mechanisms for procedural justice, there is a significant need for improvement. The thesis recommends that policymakers focus on creating more robust and enforceable rules that ensure transparency, accountability, and meaningful participation, particularly in projects that affect vulnerable communities. The study also identifies limitations and proposes areas for future research, including the need for more comprehensive and systematic approaches to assessing procedural justice in climate adaptation initiatives.

In summary, this thesis makes methodological and theoretical contributions to the field of climate adaptation policy analysis. It pioneers the application of LLMs to partially automate the labour-intensive process of coding voluminous policy documents with the Institutional Grammar syntax. It also operationalizes and refines procedural justice principles for ex-ante institutional analysis in a novel domain. By providing a systematic approach to evaluate procedural justice ex-ante, this research contributes to the development of more equitable and effective climate adaptation policies, ensuring that the needs and voices of vulnerable communities are adequately addressed in the face of a changing climate.

Preface and Acknowledgements

“Real stupidity beats artificial intelligence every time.”

- Terry Pratchett, Hogfather

It is hard to overstate how excited I am to present this work. For me, it's an important milestone in, what will hopefully be a long journey of building better public policy. I hope that the work on procedural justice, as well as the technical contributions to IG annotation, shall serve as useful contributions to the discourse. As researchers, we all benefit (in one way or another) from being at the right place at the right time. I am very privileged to be surrounded by amazing people who have inspired these ideas, and helped build my skills to execute them.

I am honoured for the opportunity to work with Amineh Ghorbani as my First Supervisor. You have been the best guide and mentor I could have asked for. Her critical feedback has challenged me to reach for more, while her generous encouragement has been a safety net. I am also immensely grateful to Sofia Gil-Clavel, a phenomenal daily supervisor who has been incredibly patient, supportive, and kind. I have also been in awe of Prof. Tatiana Filatova, my second supervisor. Her interest in my work, thoughtful suggestions and practical advice brought this project together.

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There are two people that I cannot thank enough. My partner, Rishika has been my shield and rock throughout. My mother, for everything she has done to make me who I am.

Finally, I would like to dedicate this thesis to memory of my grandmother, Jyoti; I miss you.

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Contents

Executive Summary	ii
Preface and Acknowledgements	iv
Contents	v
Tables and Figures	vii
Tables	vii
Figures	vii
1 Introduction	1
1.1 Climate Change Adaptation	1
1.2 Climate Justice and Procedural Justice	2
1.3 Research Questions	4
1.4 Structure of this thesis	10
1.5 Relevance for CoSEM	12
2 Literature Review	13
2.1 Search Procedure	13
2.2 Literature Analysis	14
2.3 Knowledge Gap	15
3 Background and Concepts	17
3.1 Perspectives on Procedural Justice	17
3.2 Institutional Analysis Framework	21
3.3 Defining Procedural Justice through Institutional Analysis	25
3.4 Empirical Analysis of A Procedural Justice Case	34
4 Approach and Methodology	38
4.1 Research Design	38
4.2 IG Coding Methodology	42
4.3 Data Collection	46

5	Method of Automated Annotation	52
5.1	Background	52
5.2	The Annotation Task	52
5.3	Large Language Models and their applications	54
5.4	Applying Large Language Models	58
5.5	System Design	59
5.6	Application Components	61
5.7	The Experiment	63
5.8	Observations	64
5.9	Conclusions	68
6	Analysis of Procedural Justice	69
6.1	Descriptive Coding of Documents	69
6.2	Analysing Action Situations	72
6.3	Comparison with World Bank Assessment	77
7	Conclusions and Future Work	78
7.1	Responding to the Research Questions	78
7.2	Limitations and Future Work	80
7.3	Conclusion	83
8	References	84
9	Annexures	98
9.1	Codebase	98
9.2	Data	98
9.3	Syntax Counts	99
9.4	Frequently Occurring Entities	100
9.5	Statements Matching Procedural Values Syntax	102

Tables and Figures

Tables

Table 1 Literature Search Query	13
Table 2 Syntax Counts by dataset	64
Table 3 Per Syntax Results	65
Table 4 Comparative Model Performance	66
Table 5 LLM Consistency	66
Table 6 Prompt Performance Comparison	67
Table 7 Comparison with Prior work	67
Table 8 Document information	69
Table 9 Statements by Phase	71

Figures

Figure 1 Complexities in implementing Adaptation	2
Figure 2 Structure of the Thesis	11
Figure 3 Dimensions of Procedural Justice, Adapted from Ruano-Chamorro (2022, p. 5)	19
Figure 5 Institutional Network Diagrams, adapted from Ghorbani (2024)	25
Figure 6 Modified IAD framework	25
Figure 7 Justice Dimensions Mapped to IAD	26
Figure 8 Institutional Diagram Representing Voice	29
Figure 9 Institutional Diagram Representing Transparency	30
Figure 10 Institutional Diagram Representing Accountability	32
Figure 11 Institutional Diagram Representing Correctability	33
Figure 12 Research Flow	38
Figure 13 IG Annotation Pipeline	52
Figure 14 Epistemic and engineering challenges	53

Figure 15 Software Architecture	60
Figure 16 Institutional Environment for Wastewater Project Development	73
Figure 17 Institutional Environment for Appeal Process	74
Figure 18 Institutional Environment for Sanitation Worker Employment	76

1 Introduction

Climate change has profoundly impacted lives worldwide. Even if the Paris Agreement's 1.5°C target is met, communities must adapt to its effects (IPCC, 2022, para. B.1.4). Climate Change Adaptation (CCA) is the process of modifying existing systems to reduce vulnerability or compensate for the impacts of climate change (Nordgren et al., 2016).

Many communities which are historically least responsible for climate change, are now highly vulnerable to its impacts. Climate Justice seeks to reduce this unjust distribution of burdens (Will & Manger-Nestler, 2021). By including community groups in decision making and leveraging indigenous and community knowledge, CCA implementers can ensure the legitimacy and effectiveness of adaptive measures (IPCC, 2022, para. C.5.3). Procedural Justice ensures this inclusion and balances the distribution of power within these processes.

1.1 Climate Change Adaptation

Adaptation is a complex and interdisciplinary issue, encompassing physical infrastructure, finance, governance, institutions, or other transformative changes – often in tandem (Owen, 2020). In the climate policy domain, adaptation i.e. adjustments to reduce climate induced damages is defined in contrast to ‘mitigation’ i.e. emission reduction efforts (Smit et al., 1999). Grecksch and Klöck (2020, p. 1) define adaptation interventions as changing the allocation of “needs, rights, decisions, [...] responsibilities, resources, and risks”.

At the heart of this, is the issue that the impacts of climate change are profoundly local, affecting communities in diverse and specific ways (Nalau et al., 2015). There is a growing emphasis on including community groups in decision making and leveraging indigenous and community knowledge, to ensure the legitimacy and effectiveness of adaptive measures (IPCC, 2022, para. C.5.3). As Owen (2020) demonstrates, successful climate change adaptation policy necessitates strategies that are tailored to individual community contexts. It must address local risks and vulnerabilities, socio-economic factors, and culture.

“Adaptation planning and implementation that do not consider adverse outcomes for different groups can lead to maladaptation, increasing exposure to risks, marginalizing people from certain socioeconomic or livelihood groups, and exacerbating inequity.” (IPCC, 2022, p. 27)

Adaptive interventions have been found to include a broad range of ‘common-sense’ investments that promote resilience (Begum et al., 2014; Vogel et al., 2007). Particularly in developing or rapidly urbanising contexts, development of water supply or water distribution infrastructure, wastewater management to preserve environmental quality, or even stormwater and drainage, may constitute an important part of adaptive capacity (Kuruppu, 2009). Contention over what investments constitute climate adaptation versus which ones are better thought of as urban infrastructure is a realm of debate (Anguelovski et al., 2016). Figure 1 maps the conceptual uncertainties associated with defining and selecting climate adaptation

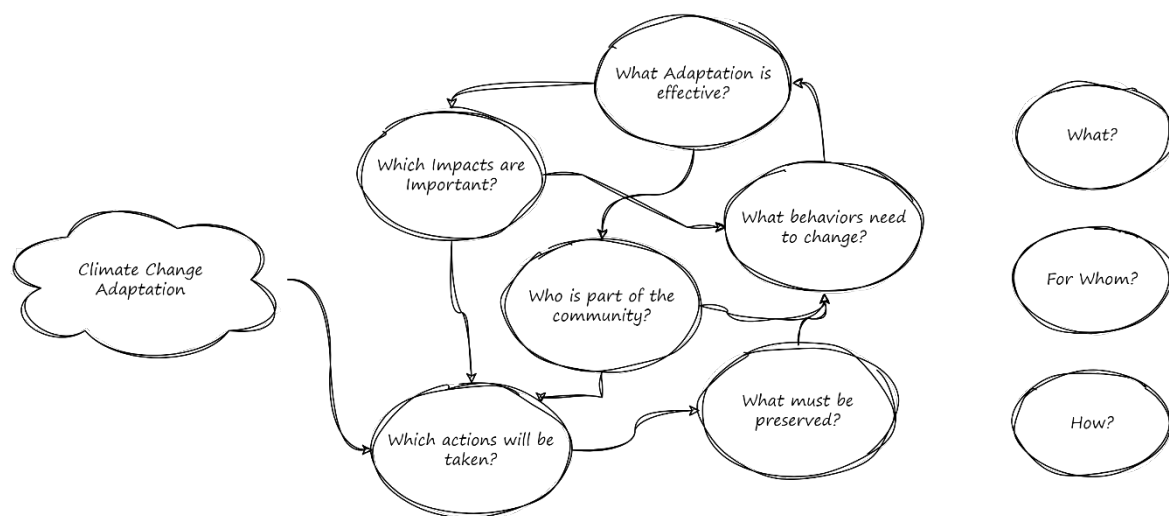


Figure 1 Complexities in implementing Adaptation

alternatives.

This contested space makes understanding decision making even more important. In the absence of clear guidance, it is left to communities to navigate these uncertainties and determine the correct course of action for them.

1.2 Climate Justice and Procedural Justice

The term "Climate Justice" emerged prominently within the discourse of climate change mitigation and adaptation with its formal introduction by the Intergovernmental Panel on Climate Change (IPCC) in its 5th Annual Report (IPCC, 2014) and further acknowledgment in the Paris Agreement of 2015 (2015). This conceptual framework underlines the intersection of climate change impacts with broader issues of justice and equity, advocating for an equitable distribution of the burdens and benefits associated with climate change (Caney, 2014). Climate justice, as emphasised in the Paris Agreement, insists on addressing both the inequity caused

by historic emissions of states, as well as the present day inequities with and across states that lead to unjust distribution of the burdens of climate change (Will & Manger-Nestler, 2021).

Another major issue in the realm of climate justice is inequity in climate resilience within countries and communities. While there is significant disparity in adaptive capacity between countries, the differences in adaptive capacity between the rich and poor within countries are often as high, if not higher (Robinson, 2020). While investments in public infrastructure may theoretically reduce these divides, it is often difficult to judge which investments are most beneficial to which groups, and if their benefits are truly experienced equitably. Examining and understanding the power dynamics intrinsic to decision making processes is one of the best ways to evaluate these impacts.

At present, most scholars follow the justice conceptions proposed by Paavola and Adger (2002, 2006), and further articulated by Schlosberg (2012). The ‘tripartite’ view of justice, as it has come to be known, defines 3 pillars of justice: ‘distributive justice’, ‘procedural justice’, and ‘representational justice’ (Friedman et al., 2018). Distributive justice concerns itself with the equitable allocation of resources and the outcomes of such distributions. Procedural justice, on the other hand, delves into the fairness of decision-making processes and the distribution of power within these processes. Representational justice questions the inclusivity of these processes, examining who is given a voice and how individual identities are acknowledged and represented within decision-making frameworks.

This view is not without its criticisms, with Cañizares et. al. (2023) providing a eloquent argument of the gaps and overlaps left by these definitions. Kortetmäki (2016) articulates the underlying conceptual flaws in the notion of distribute justice; while San Martín & Wood (2022) point out the inherent flaws in the governance systems that give rise to notions of justice and argue for centring epistemic principles for scrutiny. Nonetheless, the conception of both ‘substantive’ and ‘procedural’ justice remains a useful tool that play a key role in the Climate Justice arena (Alba et al., 2020).

In the realm of climate change policy actions, procedural justice remains underexamined compared to its counterpart, distributive justice. Evidence presented by Araos et al. (Araos et al., 2021) reveals a striking oversight: a mere 60% of global adaptation response reports make any mention of the vulnerable groups they impact. This lack of focus on procedural justice is further underscored by the findings of Bulkeley et al. (Bulkeley et al., 2013), who, upon analysing 627 initiatives across 100 cities worldwide, discovered that less than one-third of these initiatives engage with justice concerns in the context of climate mitigation or adaptation.

Notably, discussions around distributive justice outcomes overshadow those of procedural justice principles by a significant margin, being two to three times more likely to be mentioned. This disparity highlights a critical gap in the scholarly and policy-oriented discourse on climate justice, where the equitable processes of decision-making and power distribution—central tenets of procedural justice—demand greater attention and rigorous study to ensure truly inclusive and just climate adaptation and mitigation efforts.

1.3 Research Questions

This research explores the critical intersection of climate change adaptation and procedural justice. It aims to understand how the inherently complex dynamics in existing policies influence the fairness and inclusivity of project outcomes – particularly in the case of climate change adaptation projects. I particularly focus on how formal rules within policy environments can either impede or facilitate procedural justice.

Primary Question

In what ways do formal rules influence procedural justice in climate change adaptation projects?

As Chapter 2 will show, the study of procedural justice in the context of climate change adaptation is still nascent. Through this research, I seek to identify relationships between the content of formal rules in public policy, and the adherence to procedural justice values. This question can be decomposed into 3 important sub questions. The first helps define procedural justice in the context of climate change. The second, integrates the analytical approach of institutional economics with the lens of social justice. The third introduces the methodology, and data required to comment on a policy problem.

Sub-Question 3 introduces an additional challenge – the scale of the document reviews necessary to comment on a policy problem. This leads to Sub-Question 4, which explores opportunities for automating laborious steps of the analysis.

Each of these questions is discussed in detail below.

1.3.1 SQ 1: Procedurally Just Practices in CCA

Sub-Question 1

What are the key principles, or types of practices that indicate alignment or misalignment with procedural justice values in climate change adaptation?

Approach

- Explore the theoretical foundations of procedural justice
- Identify specific principles and indicators relevant to climate change adaptation projects,
- Assess evidence required to comment on the achievement of the relevant principles.
- Categorise principles by applicability to ex-ante evaluations of CCA projects

Expected Outcomes

- A prioritised list of principles that serve as evidence of procedurally just adaptation practices in CCA

While there is limited systemic study of procedural justice in the context of CCA projects, the field has a rich history of study in legal practice, jurisprudence, behavioural and organizational psychology, and social justice theory (Blader & Tyler, 2003; Hagan & Hans, 2017; Tyler, 2001). This research question will bring concepts of justice from these domains and identify them with the concerns applicable to CCA.

The systematic review in Chapter 2 demonstrates that there is little empirical evidence in the CCA domain on what behaviours – individual or group – constitute adherence to the principles of procedural justice. While Paavola and Adger (2006) advance principles (such as transparency, accountability, and legitimacy) that may contribute to the perception of justice, they fall short of a comprehensive approach. Various authors have conducted empirical studies that offer evidence for procedural justice concerns in CCA projects being substantially similar that that seen in other public goods and services. (Grecksch & Klöck, 2020; Holland, 2017; Kirkby et al., 2017)

The study of procedural justice is mature in the study of law enforcement and legal systems (C. Donner et al., 2015). The relationship between the behaviour of individuals and organisations, as well as the factors impacting perceptions of citizens in interactions with bureaucrats and other decision-makers has been the subject of extensive empirical research in the field of public administration, jurisprudence, and behavioural and social psychology (Blader & Tyler,

2003; Hagan & Hans, 2017; Tyler, 2001). This research will draw on these studies to identify practices that are aligned, or misaligned with the values of procedural justice.

1.3.2 SQ2: Institutional Perspective on Justice

Sub-Question 2

What insights about procedurally just behaviour can be derived through the institutional analysis of climate change adaptation projects?

Approach

- Identify an analytical approach to studying the influence of rules over decision-making in CCA projects,
- Reflect on the position of procedural justice in this analytical approach,
- Define the method of identifying, deconstructing, and interpreting ‘rules’ as a unit of analysis,
- Analytically define links between rules and justice principles.

Expected Outcome

- Analytical definitions for what may constitute procedurally just rules
- Criteria for establishing the presence or absence of particular rules in an institutional setting.

Institutional Economics draws links between existing formal rules and social norms (institutions); the costs, benefits, and preferences of individuals and organizations; and the choices and behaviours we see in the real world (Williamson, 2000). To understand how formal rules may facilitate or impede procedural justice in climate change adaptation policies, this analysis will leverage concepts from institutional economics.

In this analysis the presence or absence of any specific rule, viewed in isolation, cannot be considered necessary or sufficient for the achievement of specific outcomes.

Through frameworks like the IAD (Polski & Ostrom, 1999), institutional economics provides a foundation for examining the role of rules and institutions in shaping economic and social

outcomes. By focusing on formal rules in decision-making for CCA projects, this research will identify and interpret the alignment of procedural elements with justice.

Prior to applying the method to a concrete case, the study will start take an analytical approach that frames CCA within the lens of Institutional economics. The principles of justice will be overlaid in this same frame and links drawn. This analytical understanding will become the method with which specific policy settings may be understood, and against which they may be compared.

1.3.3 SQ3: Methods and Data for Institutional Assessment of Public Policy

Sub-Question 3

What data sources and methods are needed to empirically assess
procedural justice in a policy arena?

Approach:

- Identify key data sources that contain relevant policy information for Climate Change Adaptation (CCA) projects.
- Establish criteria and methodologies for defining the scope of the analysis.
- Utilize existing social impact analyses as a foundation for assessing the scope.

Expected Outcome:

- A guideline to choose the scope of procedural justice analyses in CCA projects, including identification of relevant data sources.

Climate Change Adaptation is a local, community centred issue (McNamara & Buggy, 2017), and is best assessed in the context of specific risks and values. Procedural justice is similarly centred on the specific needs and capabilities of participants in a setting. The nascency of this analysis demands an exploratory approach to data collection and analysis. An empirical analysis is necessary to address the specifics of a settings and the interventions being assessed (Yin, 2009).

The case study method is well suited to these requirements and allows a detailed and contextual examination of specific instances of policy implementation in climate change adaptation. By leveraging the case study method, this research will identify and analyse key data sources that contain information about relevant policies, focusing on government orders, and laws.

The identification of cases requires identification of interventions, aimed at CCA, with enough secondary information available to assess the institutional environment of the project in which

the intervention is being executed. The analysis will begin by selecting a particular preexisting CCA project. This restricts the scope to the identification of policies and formal rules governing a specific CCA project. By selecting projects where systematic risk assessments have been conducted, we are able to leverage the hazards, identification of vulnerable groups, and a list of project activities from which one can determine applicable policies. Existing social impact analyses will serve as a foundation, offering insights into the broader societal implications of these policies and helping to frame the scope of the analysis.

For the selected case – policy documents relevant to the intervention must be systematically reviewed. Formal methods of analysis typically involve detailed content annotation of policies to enable reproducible analysis. Complex documents are annotated to extract information pertinent to procedural justice. This effort required to do this manually often poses a pragmatic limit on the scope of such analysis and serves as a significant barrier to the usefulness of analyses. In Sub-Question 4, I explore if the effort required at this stage can be reduced.

1.3.4 SQ4: Automating Policy Analysis

Sub-Question 4

How can recent advances in Large Language Models (LLMs) support the automated analysis of policy documents for procedural justice?

Approach

- Develop and validate an automated annotation tool
- Compare the performance of new automated tagging methods with manual annotation and other NLP techniques.
- Identify an analytical approach to studying the influence of rules over decision-making in CCA projects,
- Reflect on the position of procedural justice in this analytical approach,
- Define the method of identifying, deconstructing, and interpreting ‘rules’ as a unit of analysis,

Expected Outcomes:

- Demonstrating LLM based tagging outperforms NLP on component level tagging tasks for single sentences
- Applying LLM based tagging on complex compound sentences
- An automation tool suited to analysing institutional statements in policy documents.

This sub-question responds to a significant methodological limitation of the Institutional Grammar, and Institutional Network Analysis. The approach chosen for SQ 3 is limited by a pragmatic consideration – namely, that policy documents are often voluminous and complex. They may have references to various external texts, and implicit reliance on existing legal frameworks. Depending on the authorship, a single natural language statement may contain multiple institutional statements, or several pages of text may parse down to a single statement (Frantz & Siddiki, 2022; Rice et al., 2021). This makes coding of institutional statements labour intensive and challenging.

To address these challenges, advancements in machine learning, particularly computational text analysis and natural language processing (NLP), offer promising solutions. Stanford Core NLP, for instance, achieves over 90% accuracy in Parts-of-Speech Annotation. Yet, deep learning's effectiveness in tagging IAD elements stands at approximately 74%, still necessitating manual identification of relevant statements (Rice et al., 2021). Additionally, NLP based tagging methods perform poorly on differentiating between grammatically similar components, or identifying multi-word components. They are also unable to classify nested statements, such as the Activation Conditions, or the 'Or Else' (Wróblewska et al., 2023).

Recent developments in generative pretrained language models (LLMs) present new possibilities. LLM applications in policy analysis range from generating policy briefs to annotating the sentiment of discourse or classifying policy content. These models could potentially enhance NLP techniques by directly generating 'parsed' IG statements from textual data, thus facilitating deeper syntactic and semantic analyses.

The detailed methodology for developing and validation this method is presented in Chapter 3. The following objectives summarise the goals of the LLM based methodology for IG tagging.

1.4 Structure of this thesis

So far, in Chapter 1 I have introduced the subject and defined the Research Questions. Figure 2 shows these sub-questions and the forthcoming Chapters. It links each section with its corresponding sub-question.

Chapter 2 reviews the existing literature to identify the current state of knowledge and gaps that this research aims to fill. Chapter 3 will provide additional background and explain key concepts utilized in this study, including perspectives on procedural justice, the Institutional Analysis and Development (IAD) framework, and how the IAD maps to procedural justice dimensions. It is divided into 3 sections. Chapter 3.1 directly answers SQ-1, while Chapters 3.2 and 3.3 collectively answer SQ2. Chapter 4 and 5 respectively address SQ 3 and SQ4.

In Chapter 4 the methods for Institutional Analysis are discussed, and the selected approach, research design, case study selection, and the use of the Institutional Grammar (IG) is presented.

Similarly, Chapter 5 establishes the need for automation, the approach used to develop automation, the system architecture, and the validation of the designed system.

Finally, Chapter 6 applies these tools to a case study, and presents the results of the analysis. This is where I answer the main research question, and conclude the exploratory aspect of the case study.

In Chapter 7, the broader findings are presented and synthesized. The implications for the study of climate justice, and the broader field of institutional analysis and public policy are discussed. The limitations of the current study, directions for future research, and abandoned concepts are presented.

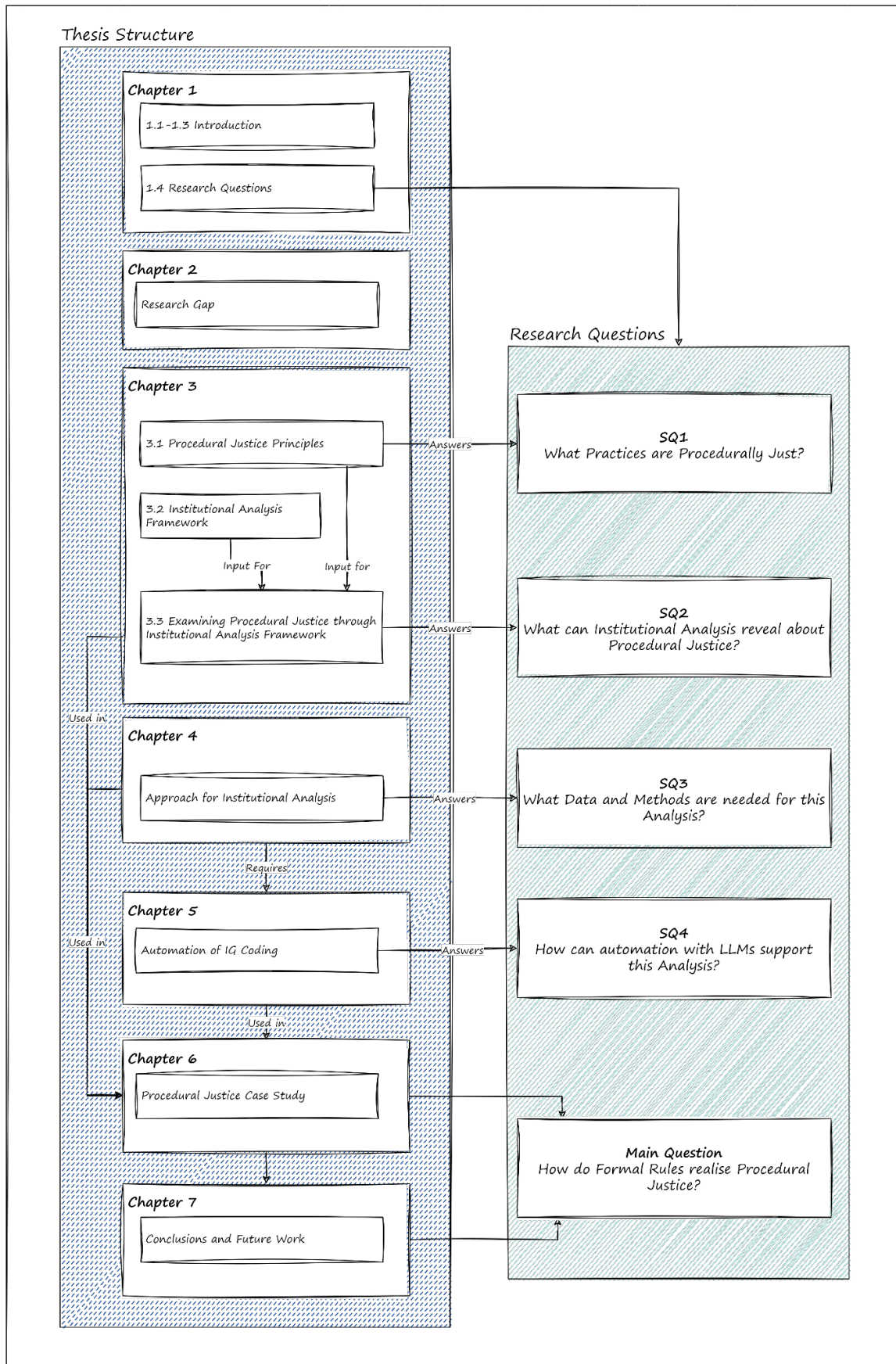


Figure 2 Structure of the Thesis

1.5 Relevance for CoSEM

This research aligns seamlessly with the Complex Systems Engineering and Management (CoSEM) program and the broader objectives of the Faculty of Technology, Policy, and Management by addressing a critical intersection of technology, policy, and societal needs. Firstly, the focus on climate change adaptation underscores the program's commitment to tackling pressing global challenges through innovative systems thinking and management strategies. Climate Change Adaptation is a multi-actor problem, that even notwithstanding uncertainties around technical decisions, is fraught with conflict on the correct ways in which to execute those decisions.

The use of the Elanor Ostrom's Institutional Analysis and Development (IAD) framework, a cornerstone theory within CoSEM for policy design, further exemplifies the research's relevance. The application of the IAD to assessing procedural justice is novel and presents an opportunity to gain new insights and push the framework further.

This research leverages recent advancements in Large Language Models by designing and piloting software that automates the tagging of documents with the Institutional Grammar. The introduction of this tool significantly improves over the state of the art – by improving the accuracy and the volume of statements that can be tagged. The architecture of the software tool represents a design contribution of the field of policy analysis.

2 Literature Review

To further substantiate the current knowledge around climate change adaptation and the assessment of procedural justice in this domain, a systematic review of literature was performed. The aim was to identify studies focusing on procedural justice in the context of climate change. The search was performed on the Scopus Database (ELSEVIER 2023).

2.1 Search Procedure

A search was conducted on the Scopus Database, to identify any articles that discuss ‘procedural’ justice in the context of ‘climate change adaptation.’

Table 1 Literature Search Query

Query	Results
TITLE-ABS-KEY (procedu* PRE/1 (fair* OR just*)) AND TITLE-ABS-KEY (("Climate Change") AND (adapt*))	41

The search results range from 2005 to 2023, consisting of 34 articles, 1 conference publication, and 3 reviews and 3 book chapters. Over 50% of the papers were published in or after 2020. From this set, the book chapters were removed due to their length.

To ensure that approaches are grounded in practical aspects of policy design and implementation, the emphasis is on literature that engages with specific cases of policy design or implementation. Thus, the preference was toward articles that deeply analyse a handful of policy instances through the lens of procedural or (more broadly) climate justice. Articles taking a broad approach, comparing across 10s or even 100s of policies and programs or providing of review of articles in the domain are also included for their context-setting value. Articles engaging with justice or policy at a purely theoretical or principal level are however excluded.

A further 6 were eliminated after reviewing the abstracts due to language barriers, lack of relevance, and lack of full text availability. Based on the above criteria, a final shortlist of 18 articles was reviewed.

The literature review was conducted using a systematic qualitative review method. There were five themes to be extracted from each article –

1. Type of climate policy assessed,

2. Case study used,
3. Definition / principles that exemplify procedural justice,
4. Method of assessment and comments on policy,
5. Results

The full text of each article was read and any statements corresponding to the 5 themes were annotated. The annotations were then summarised to extract key insights. 16 papers were included in the final review, the results of which review are presented below. The detailed literature analysis is presented in Annex 1.

2.2 Literature Analysis

The 16 papers analyse a mix of National, Regional and Local case studies of climate change adaptation. Excluding Bulkeley et. al, which is an outlier, 15 papers address 100 case studies of climate change adaptation policy. Of these, 36 were national or regional policy cases, while the remaining are local-scale case studies or interventions.

The articles cover a broad range of policy instruments, from community level program implementation to national legislation. The discussion of procedural justice in all cases centres on the relationship between an individual impacted by the policy, and their perception of the policy design. Scholars consistently define procedural justice as being linked to the experience of project affected groups, with an emphasis on vulnerable groups and/or those whose 'interest are not served by the policy design.'

While there isn't a consistent shared definition of procedural justice, or a unified taxonomy of the principles from which it may be assessed, some common themes are addressed by multiple authors. Paavola and Adger's (2006) principles are cited frequently – which may be summarised as meaningful consultation, knowledge sharing, and mutual respect and dignity. Authors also variously mention political power, perceived fairness, legitimacy, informed consent, transparency, and accountability as possible indicators of procedural fairness. None of these have been rigorously defined, made mutually exclusive, or articulated with dependencies or hierarchies. However, they indicate a broad understanding tied to individual and collective perception and influence and set the stage for further inquiry.

A recurring theme across these studies is the significant role of formal policy directives and the modifications introduced during implementation by street-level bureaucracy. Interestingly, none of the papers suggested a lack of awareness among policymakers or implementers

regarding the importance of procedural justice. Rather, they highlighted consultation processes or discussions with stakeholders, and in many cases policy makers believe the consultation has been performed to the best of their ability.

Nonetheless, a significant theme of a lack of ‘meaningful participation’ emerges. To evaluate whether an intervention was procedurally just, approach taken by all but 2 of the studies presented, may be divided into one of two categories. In the first approach, such as that of (Holland, 2017; W. Zhou et al., 2021), the approach consists of assessing the distributional or substantive outcomes of a policy. The rationale being that a procedurally-just policy design must also lead to distributionally-just outcomes. In the alternative, more popular method, authors perform a qualitative assessment, focused on data from stakeholders. These may include professionals, bureaucrats, direct beneficiaries, unreached or excluded groups, and other advocates or observers. Reported satisfaction or dissatisfaction with the policy design, and the various group’s perceptions are then used by the author to assess where the policy design may be improved. Some authors (Mahlanza et al., 2016) take a direct, field assessment approach, while others like (Shi, 2021) use secondary data. In either case, the argumentation still depends on an ex-post (after the fact) analysis of the case-study.

Both methods have a few key weaknesses. First, there is the attributional gap between the policy’s design and the observed outcomes. Since, even an unjust policy design may lead to fair outcomes under the right circumstances. Second, these methods are only effective in retrospective evaluations, and may do little to inform decision makers when policies are being designed. Third, even if there is compelling evidence that a policy design was unfair, it still does not translate to specific prescriptions of what needs to change about the policy or the policy environment.

The only method taking an ex-ante (before the fact) approach is (Juhola et al., 2022). Their study encompassed both national and local policy, and attempted to frame and validate an index to assert if a policy was just, based purely on the policy documents. The approach suffers from the exact weakness identified by the ex-post assessments – the inability to distinguish between ‘meaningful’ and ‘shallow’ consultations or engagement, and the lack of normative guidance towards addressing these gaps.

2.3 Knowledge Gap

Overall, the knowledge available regarding procedurally just climate change adaptation is limited, and highly reliant on empirical evaluations of policy interventions. Moving toward a

more comprehensive theory of what interventions enable the realisation of procedural justice, will require significant work from across domains.

The literature review reveals several key gaps in the current understanding of procedural justice in climate change adaptation (CCA) projects. Firstly, there is a lack of consensus on the definition and principles of procedural justice in this context. While authors often refer to Paavola and Adger's (2006) principles, there is no unified taxonomy or hierarchy of these principles.

Additionally, the literature highlights the significant role of formal policy directives and street-level bureaucracy in shaping procedural justice outcomes. However, there is limited understanding of how specific institutional structures and rules influence the realization of procedural justice principles. A more systematic analysis of the relationship between institutional design and procedural justice is necessary to develop actionable insights for policymakers.

Lastly, the integration of procedural justice considerations into the broader framework of climate justice remains underdeveloped. While distributive justice outcomes are often emphasized, the role of procedural justice in achieving equitable and effective CCA is not well articulated. A more holistic understanding of the interplay between procedural, distributive, and representational justice is needed to advance the theory and practice of climate justice.

Addressing these knowledge gaps requires interdisciplinary collaboration across fields such as public policy, institutional economics, social psychology, and climate science. By bridging these domains, researchers can develop a more comprehensive and actionable theory of procedural justice in CCA projects, contributing to more equitable and effective climate adaptation efforts.

3 Background and Concepts

3.1 Perspectives on Procedural Justice

3.1.1 Justice as Values: Philosophy and Ethics

The ethical foundations of Procedural Justice, as formulated in climate justice literature, have their roots in the Rawlsian Tradition (Rawls, 2005; Shabliy et al., 2022), as well as in the Capabilities Approach as considered by Amartya Sen (Schlosberg, 2012; Sen, 1985).

While the concept of ‘justice’ and the need for ‘fairness’ in matters of law and public policy stretches back to classical philosophy, most modern theories of justice stem from the work of John Rawls (Garthoff, 2014). In his seminal work, ‘A Theory of Justice,’ Rawls proposed the existence of ‘Pure Procedural Justice’ – i.e. situations where a-priori agreement on what constitutes a ‘fair’ outcome is impossible. These are situations where ‘justice’ is ‘purely procedural.’ When participants mutually agree to rules, and adhere to the rules, the outcome achieved through the rules is ‘just’ by definition.

While this approach is not without its criticism the relationship between the shared understanding of justice and the legitimacy of decision-making processes is widely accepted. This has been demonstrated in psychology and organisational behaviour, through the work of Morris and Leung (2000), and Blader and Tyler (2003). They revealed that when individuals perceive a process as ‘fair’ they are more likely to accept adverse outcomes that result from it. Tyler’s work demonstrated that perceptions of fairness lead directly to institutional legitimacy – essential for compliance with laws and authorities.

Amartya Sen, in his work "The Idea of Justice," (2009) takes Rawls' focus on ideal theory and applies it to the study of real-world injustices. The ‘Capabilities Approach,’ as it has come to be known, moved away from looking at direct resource distribution, and instead at the ‘capabilities’ that are achieved by an individual. This implies not only ‘ownership’ over material goods or assets, but also the social, political, and personal agency to make decisions and benefit from those outcomes. This once again reinforces ‘choice’ as a determinant of what is ‘just’ independent of the distributional outcomes involved. Together these constitute the modern deontological approach.

3.1.2 Empirical Perspectives in Procedural Justice

So far, the research has explored a deontological approach to identifying procedural justice. In contrast, there is also a teleological approach to understanding justice, emphasizing what participants perceive to be just. These perspectives have been the subject of study through empirical methods including experiments and empirical studies of case studies.

Tyler (1994) shows that ‘procedural justice’ is a distinct motivation, and that individuals assess it independently of the material outcomes. Several subsequent behavioural studies have also demonstrated that individuals are more satisfied by positive outcomes, and less dissatisfied with negative outcomes, when they perceive processes as ‘procedurally fair.’

Attributes of procedural justice such as direct participation have been shown to contribute to these perceptions under experimental conditions (Cohn et al., 2000). A primary challenge for scholars of procedural justice has been operationalising it for empirical evaluation. Research across domains ranging from urban planning to marine conservation tends to draw evidence of ‘participation’ and ‘meaningful engagement’ from either the stated goals and actions of decision makers, or from the assessments of project affected groups after projects have concluded (Gomez & Nakat, 2002). The former suffer from the inability to distinguish between ‘token’ and ‘meaningful’ efforts. The latter is redundant, since the intervention is already concluded, and the insight applicable to a new situation will be limited.

3.1.3 Identifying Procedurally Just Climate Interventions

To address the need for a systematic approach to procedural justice, Ruano-Chamorro et al. (2022) propose a taxonomy of procedural justice tailored for environmental conservation efforts. This framework identifies 11 criteria organized into three domains: process properties, agency of participants, and interpersonal treatment, underpinned by the dimension of recognition. These criteria provide a comprehensive foundation for assessing and promoting procedural justice in climate change adaptation, which shares many characteristics with conservation, such as contested spaces and the necessity for community acceptance and cooperation.

The framework highlights key attributes of procedural justice, such as transparency, accountability, and neutrality, which are essential for fair decision-making processes. It also emphasizes the importance of agency, ensuring that stakeholders have the voice, decision control, and capabilities to influence outcomes. Interpersonal treatment, characterized by respect and politeness, further enhances perceptions of fairness and legitimacy.

Integrating these criteria into climate adaptation policies can identify gaps and guide necessary changes to ensure procedural justice. This comprehensive approach fosters collaboration and trust among stakeholders, essential for effective and sustainable climate adaptation measures.

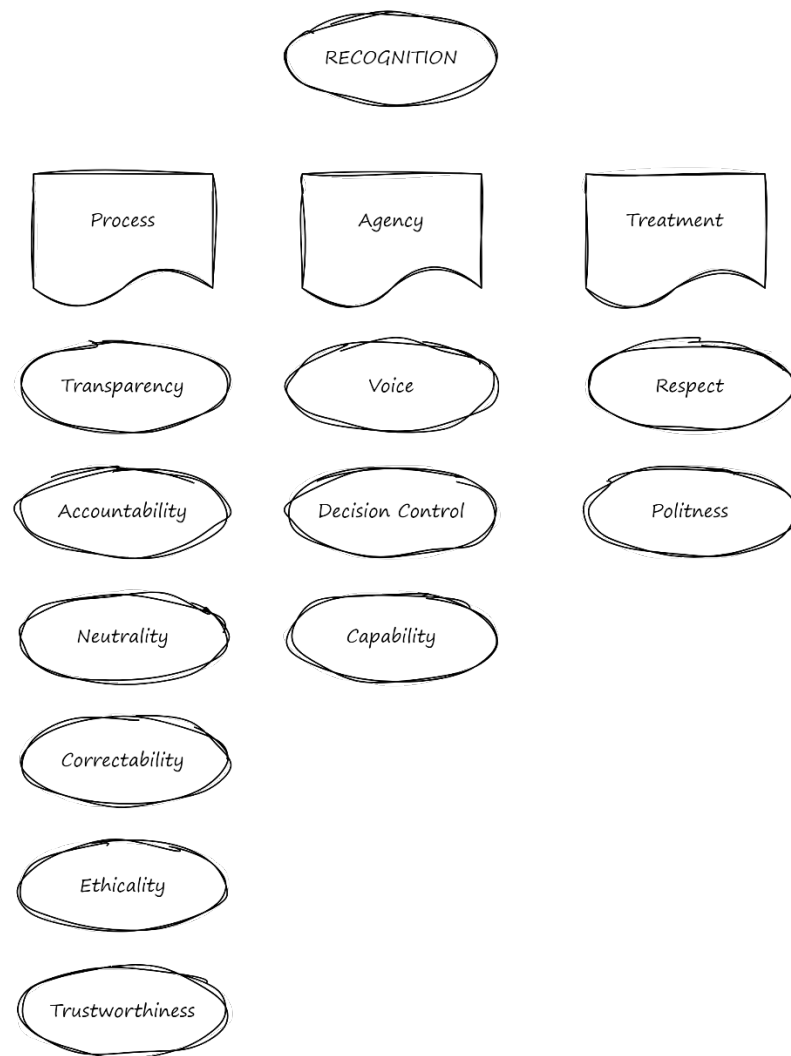


Figure 3 Dimensions of Procedural Justice, Adapted from Ruano-Chamorro (2022, p. 5)

Figure 3 shows the Dimensions of procedural justice, divided into the 3 broad categories. Each dimension is defined below.

Recognition is a foundational justice dimension that underpins the other procedural justice domains by acknowledging and respecting sociocultural diversity, values, identities, knowledge systems, and rights.

Transparency: This involves making the decision-making process visible, clearly communicating reasoning, goals, and expectations from the outset, and providing information in an appropriate form and timeframe.

Accountability: It is the ability to hold decision-makers responsible for their decisions and ensuring they are answerable to the people affected by those decisions.

Neutrality: Achieved when participants perceive decisionmakers as unbiased, and making accurate use of information, providing honesty, and consistent treatment across time and people.

Correctability: When processes allow decisions to be modified or reversed through established mechanisms. This is important not only in cases of corruption but also for errors and accidents.

Ethicality: When decision-making processes conform to participants' moral standards – it is tied to cultural perceptions of bribery, privacy, empathy, and flexibility.

Trustworthiness: Tied to the perception of decision-makers themselves, generally to their motivations, and contributes to acceptance of short-term long-term trade-offs.

Voice: Participants' ability to express needs, dissatisfaction, priorities, and influence. It does not require tangible decision control.

Decision Control: Participants' capacity to control or influence decisions, shaping outcomes.

Capabilities: The material resources, knowledge, skill, and political capacity to exercise the voice and control in a particular situation.

Respect: When participants perceive that they have been treated with dignity.

Politeness: Deeply tied to respect, includes courteous and considerate behaviour in interactions – implies acknowledgement of norms and practices.

At this stage, one challenge remains – many of these criteria can only be assessed once a policy has materialised. For instance, the evaluation of 'Respect' is unlikely to be possible without assessment of a direct interaction between a stakeholder and decision-maker. In this research I focus on attributes that may be evaluated ex-ante. For instance, one may comment on Transparency simply by assessing whether requirements for disclosure exist. In Chapter 3.2, I introduce the Institutional Analysis Framework, through which this study will understand these values, and their manifestation in formal rules.

3.2 Institutional Analysis Framework

Increasingly, climate change is understood not only as a technical or technological problem, but also as a social and economic one (Havukainen et al., 2022; Oberlack, 2017; Thaler et al., 2019). Adaptive capacity of socio-ecological system is subject to soft limits – i.e. those limited by the financial, political, governance, or cultural systems at play in an environment (Andrijevic et al., 2020; Mortreux et al., 2020; Siders, 2019). The IPCC calls for “mainstreaming adaptation into institutional budget and policy planning cycles, statutory planning, monitoring and evaluation frameworks and into recovery efforts” (IPCC, 2022, para. C.5.2).

Public policy is often highly abstract, and frequently contain hidden complexity. Even when they are completely formal, which in most cases they are not, the factors influencing individual and group decision making in various contexts is difficult to document. Institutional Analysis (or Institutionally Oriented Policy Analysis) is the systematic study of these factors, through tools and methods suited to observing and communicating the factors that influence decision and lead to observable interactions and outcomes (Polski & Ostrom, 1999).

An institution in the Ostromian sense is any set of measures or social structures that aim to influence behaviour within an 'Action Situation' or setting. Any real-world objective, such as CCA is composed of several action situations, linked together in time and space. Institutions operate within and across these boundaries, interacting to modify the behaviour of actors, their environment, and themselves.

The application of Institutional perspectives in CCA literature is still nascent, with notable application of the method to (Bisaro et al., 2018; Carter et al., 2016; Roggero, 2015). More recently, (Ghorbani et al., 2021; Mesdaghi et al., 2022) demonstrate the application of institutional analysis methods to describing and commenting on effectiveness of climate adaptation policy. The current research builds on the methods and tools developed there to further the theoretical framework. These tools are summarised here:

3.2.1 IAD Framework

The Institutional Analysis and Development Framework is an influential toolkit, used to formulate, implement, and evaluate policy. It is used in consort with the Institutional Grammar – a syntactic standard for interpreting and expressing the underlying institutional meaning embedded in language. The IAD Framework posits that the decisions taken by actors in policy settings are influenced, or constrained by the institutions in the situation (Polski & Ostrom, 1999).

The Institutional Analysis Framework frames the identification of institutions in reference to a policy system, which consists of numerous overlapping and interconnected ‘Action Arenas’ within which actors take actions (Polski & Ostrom, 1999). The analyst, in choosing the bounds of the policy system, and framing action arenas, frames the analysis. Figure 4 shows the important components of the IAD Framework.

Action Arena: These are the focal points where actors interact, make decisions, and engage in behaviours, and evaluate results. Each action arena comprises an action situation and the actors involved, as well as the necessary constituent material and institutional environment.

Action Situations: These are the social spaces where individuals or groups interact, exchange goods and services, solve problems, or engage in conflict. The rules-in-use, physical conditions, and community attributes influence these situations. These are not necessarily well-defined physical spaces with discrete temporal bounds, but instead a unit of shared experience.

Actors: These are individuals or groups who participate in the action situations. Their preferences, information, and strategies shape the outcomes.

Rules-in-Use: These are the formal and informal guidelines that govern the interactions within action arenas. They can be operational, collective-choice, or constitutional rules.

Material and Physical Conditions: These refer to the biophysical and material conditions that affect and are affected by the action situations. This includes the natural environment, infrastructure, and resources available, which influence the feasibility and outcomes of different actions within the action arena.

Attributes of the Community: These include the social and cultural characteristics of the community involved in the action situation. Factors such as shared norms, values, historical experiences, and the level of trust among community members play a significant role in how institutions function and how effective collective action can be.

Interactions and Outcomes: These are the choices made by the actors, the effect of the choices on other participants, and results of those actions. Outcomes directly impact the state of the world in the future, and are incorporated into the future decision making of actors.

3.2.2 Institutional Grammar

In the realm of institutional analysis, capturing the essence of rules, norms, and strategies that guide human interactions is crucial. Institutions, defined broadly as the prescriptions that humans use to organize all forms of repetitive and structured interactions, shape the behaviour and outcomes within any given policy setting. However, dissecting these institutions to understand their impact and functionality requires a systematic approach. This is where the Institutional Grammar (IG) comes into play.

The need for IG arises from the complexity and diversity of institutional statements. These statements can be found in laws, regulations, policies, and even informal social norms. To analyse and compare these institutions effectively, a standardized method for parsing and interpreting institutional statements is essential. Without such a framework, it would be challenging to identify, compare, and evaluate the varied institutional arrangements across different contexts.

The Institutional Grammar provides a tool to systematically identify institutional statements inside policy documents. It enables the systematic coding of discrete 'institutional directives'. The particular approach in this project will be aligned to the IG2.0 Core specification (Frantz & Siddiki, 2022), which builds on the foundations laid out by Ostrom.

Institutional Grammar 2.0 (IG 2.0), is an evolution of the original Institutional Grammar developed by Crawford and Ostrom in 1995, offers a refined method for systematically dissecting institutional statements. IG 2.0 Core addresses the need for a detailed, component-based analysis of institutions, enhancing the ability to compare and evaluate institutional arrangements across different contexts.

The original Institutional Grammar was designed to parse institutional statements into their syntactic elements: Attribute, Deontic, Aim, and Condition. These elements provided a structured way to analyse the components of rules, making it easier to compare formal institutions (institutions-in-form) with their practical implementation (institutions-in-use).

IG 2.0 Core expands and refines this approach by incorporating additional components and providing a more nuanced understanding of institutional statements. The key components of IG 2.0 Core are:

Attribute: The actor who is expected to carry out or refrain from carrying out the action.

Deontic: The prescriptive or permissive operator defining the extent to which the action is compelled, restrained, or discretionary.

Aim: The action itself that the statement prescribes.

Object: The inanimate or animate part of the statement that receives the action, which can be further delineated as **Direct Object** or **Indirect Object**.

Context: The settings in which the action applies, divided into **Activation Conditions** (which instantiate settings for the action) and **Execution Constraints** (which qualify the action).

Or Else: The sanctioning provision associated with the action, indicating the consequences of non-compliance.

By breaking down institutional statements into these components, IG 2.0 allows for a more detailed and precise comparison of how institutions are designed versus how they are implemented. This level of analysis is particularly useful for identifying discrepancies between institutions-in-form and institutions-in-use, which can reveal underlying issues in policy implementation and effectiveness.

3.2.3 Institutional Network Analysis

Institutions rarely exist in isolation. In most cases, common actors, situations, and overlapping resources create links and dependencies between institutions. Institutional Network Analysis (INA), is a framework for studying institutional interdependency as well as identifying institutional voids and points of conflict (Ghorbani, 2022; Mesdaghi et al., 2022; Ostrom, 2014). To develop an institutional network, we begin by analysing documents (such as laws, government policies, reports, or interviews) that provide evidence as to the formal or informal institutions practised or perceived by actors. These institutions are further linked by identifying procedural and technical dependencies that turn into relationships. Figure 5 shows the syntax to represent an institutional network.

Through the INA, previously invisible dependencies, conflicts, overlaps, voids, and conformance issues between institutions become visible. Ghorbani et al. (2024) present a standardised symbology for drawing IG components, as well as guidelines for identifying valid connections between institutional statements. These guidelines have formed the basis for the work presented here.

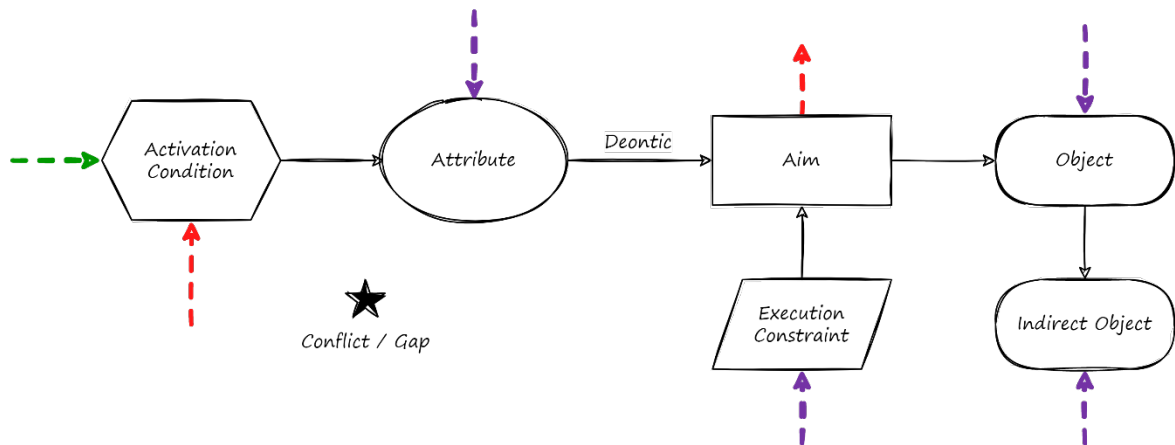


Figure 4 Institutional Network Diagrams, adapted from Ghorbani (2024)

3.3

Defining Procedural

Justice through Institutional Analysis

Consider an action areas which contains a decision maker and a participant which will interact on a decision of some significance. Procedurally just practices may be interpreted as the desired behaviour of actors in certain critical action situations. This involves systematically identifying the formal rules embedded in policy documents and deconstructing them to understand their implications for procedural justice. The rules will be treated as the fundamental units of analysis, dissecting their structure and function within the broader policy environment.

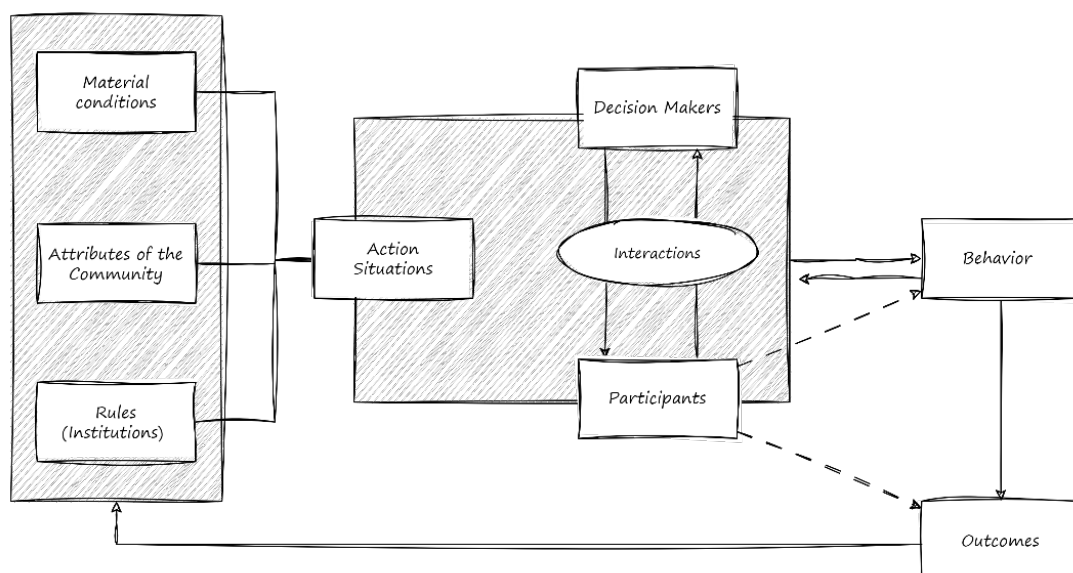


Figure 5 Modified IAD framework

Applying the IAD framework to this abstract situation a slightly modified structure emerges.

Figure 7 shows a modified action situation with the distinction between the decision makers and other participants of the Action Arena clearly separated. Based on the material, social and institutional attributes of the situation, the actors engage in behaviors that result in outcomes. We have established that procedural justice may be evaluated in the attributes of the community, in the actions of the decision maker, or in the perceptions of the participants. Thus, while the outcomes themselves are not features of interest, the participant's perceptions of those outcomes are significant features.

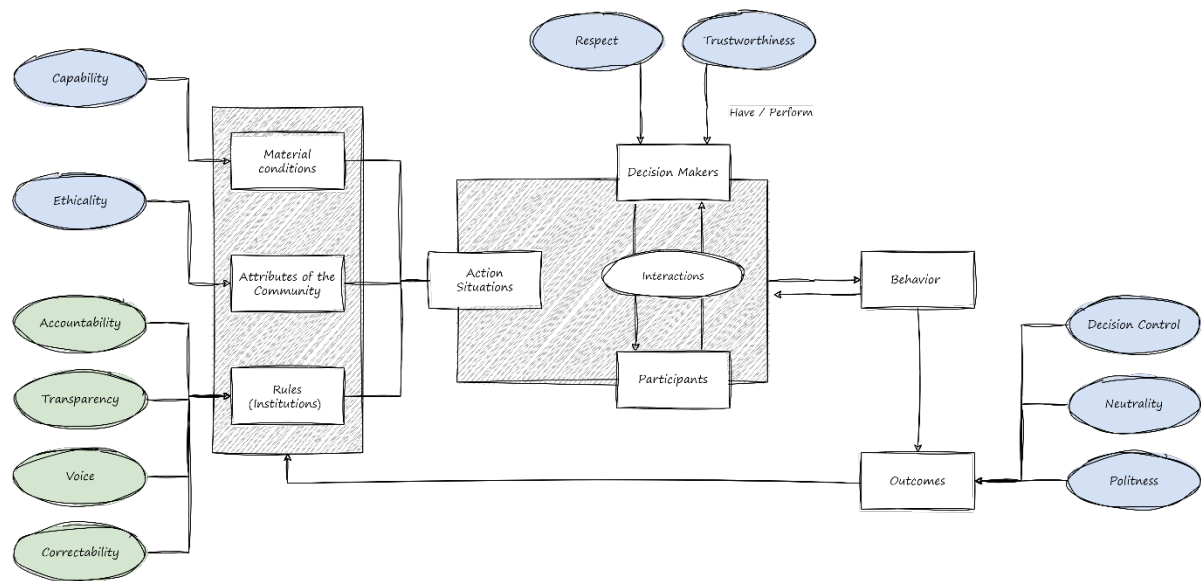


Figure 6 Justice Dimensions Mapped to IAD

We can map the various dimensions of procedural justice to the elements of this Action Arena. Consider 'Respect' and 'Politeness' – dimensions of interpersonal justice. While cultural context and power dynamics influence both, Politeness may only be assessed once it has manifested in the behavior of an individual. Similarly, Respect is an internal state of a participant and cannot be directly evaluated. The same is true for Neutrality and Trustworthiness – the lack of bias within a decision, or the intent of a decision maker to follow through on commitments can only be assessed in the context of specific actions and individuals, or not at all.

'Capability' is a dimension that addresses the resource availability of the group. In any given action situation, the capabilities of a group are related to their material conditions. Similarly, 'Ethicality' is dependent on the shared understanding of morality embedded in culture. Thus, in the IADF these dimensions map to the Material Conditions and Attributes of the Community, respectively. Thus, by elimination, Accountability, Transparency, Voice, and Correctability are the 4 dimensions of procedural justice that may be associated with the Rules-in-Use of the action situation.

3.3.1 Measures of the Dimensions

Voice

Inclusivity and participation in public policy have largely focused on assessing group values and measuring alignment between policy action and surveys of public opinion. Empirical measurement of alignment on specific issues, such as that demonstrated by De Graaf (2015) highlight the recognition and successful or unsuccessful management of conflicting values. Other researchers have attempted to evaluate the extent of citizen engagement particularly to assess representation of vulnerable perspectives in decision-making. Burnier (2003) examines voice from a gender perspective, stressing the need to include marginalized voices in public administration research. Fang (2019) similarly, studies public service advertisements to understand the relationship between advertisers and the audience.

Moore (2015) generalizes these approaches through tools like public value mapping (PVM) and the public value scorecard (PVSC) to measure alignment with public consensus and citizen attitudes. However, all these approaches suffer from the limitation of examining instances of policy 'behavior' and suffer from limited insight into the nature of decision making that leads to alignment or misalignment.

Transparency

Measuring "Transparency" involves evaluating the accessibility and comprehensiveness of public information, the openness of decision-making processes, and the accountability mechanisms in place. Various authors have attempted to collect evidence of transparency in public administration processes. Across studies (Androniceanu, 2021; Pollifroni & others, 2015) records of public consultations, transparency reports, citizen feedback mechanisms, and participatory budgeting processes are incorporated into the evaluation of 'transparent processes. Cuadrado-Ballesteros et al. (2023) review transparency practices, and identify the role of 'documentation' as evidence from transparency. Douglas and Meijer (2016) find that higher transparency, especially regarding the authorizing environment, correlates with higher public value scores.

Accountability

To assess "Accountability," research has focused on clarity of roles and responsibilities, the effectiveness of oversight mechanisms, and the presence of reporting and feedback systems. Beu and Bukley (2004) discuss accountability as a moral, legal, and ethical obligation. In

practice, power relations and hierarchical and political power play an important role in enabling accountable practices in public administration.

Correctability

Correctability is relatively understudied in public administration literature, with many authors conflating the legal ability to change decisions with 'Accountability' which emphasizes power relations. Faulkner and Kaufman (2018) compares various public value measurement frameworks to understand how correction mechanisms are integrated within different administrative contexts. They also underscore the evolution of frameworks that now include specific procedures for corrective actions and value assessments.

3.3.2 Linking Procedurally Justice Principles to Institutional Structure

The objective of this section is to establish an analytical framework to assess whether the principles of procedural justice are upheld within a system of rules. This involves creating a clear analytical linkage between specific rules and the defined principles of procedural justice. The ultimate aim is to formulate precise, analytical definitions that can guide the evaluation of procedural justice in a case study focused on climate change adaptation.

Let us consider each practice, and examine what evidence has been used in the literature to support its existence.

Voice: Expression of Opinions

Public participation, a cornerstone of democratic values, has been extensively studied in public management literature. The principle of 'Voice' extends beyond the mere ability to make a statement. The metaphor of 'shouting into the void' often illustrates how vulnerable citizens perceive public consultations. However, to maintain a precise definition and isolate the existence of a rule from socio-cultural factors influencing its implementation, we propose the following institutional operationalization of voice.

The essence of the 'Voice' principle is ensuring that stakeholders are not only heard but that their inputs are acknowledged and addressed. This principle acknowledges the fundamental right of individuals and groups to express their opinions, concerns, and suggestions. Here, we stop short of requiring mechanisms that ensure stakeholders' inputs influence decision-making processes – since these are encapsulated in the value of Decision Control. Instead, we simply ensure that public inputs result in the base minimum acknowledgement of the communication, and these inputs are enshrined as a matter of public record. Hence, the true operationalization

of 'Voice' necessitates an institutional framework where stakeholder input is solicited, recorded, and acted upon.

A rule operationalizes 'Voice' when:

- It allows a stakeholder to make a statement, send a communication, or provide input,
- And mandates that a decision-maker respond, acknowledge or otherwise act due to, or on communication.

Using the IG2 syntax, the pair of institutions can be structured as follows:

[Stakeholder] (A) {may / can} (D) {send, communicate, raise, dispute, discuss etc.} (I)
{letter, complaint, suggestion etc} (O-D)

AND [Decision-Maker] (A) {must / shall} (D) {respond, reply, address, investigate etc.} (I)
{complaint, suggestion etc.} (O-D)

This institutional structure formalizes the requirement that stakeholders can express their views and that those in power must respond. By ensuring that decision-makers are mandated to respond, it is possible to measure the extent to which 'Voice' is truly operationalized within a given institutional framework. This structure not only encourages participation but also builds trust between stakeholders and decision-makers, fostering a more inclusive decision-making process.

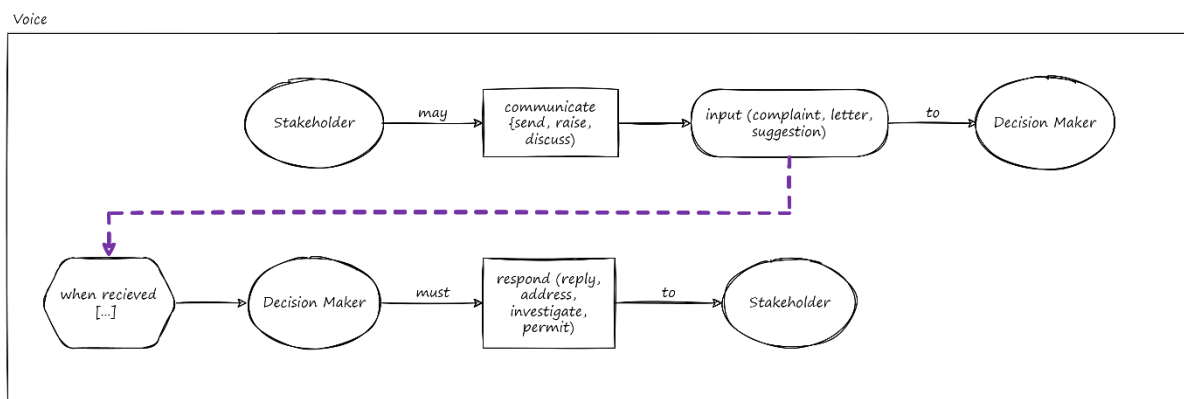


Figure 7 Institutional Diagram Representing Voice

Transparency: Communication of Information

Complementing the notion of 'Voice,' transparency pertains to public access to information about actions, plans, and schemes. In public policy literature, the material production of transparency involves creating documentation and making it accessible. The definition of

'accessible' is often tied to the capabilities of the stakeholder and is therefore outside the immediate scope of this analysis.

Transparency is vital for procedural justice as it ensures that all stakeholders have access to the information necessary to understand, evaluate, and influence decisions that affect them. Transparency in decision-making processes builds trust and accountability, allowing stakeholders to monitor and evaluate the actions of decision-makers. It also reduces the likelihood of corruption and enhances the legitimacy of the decisions made.

However, since the stakeholder's ability to access, interpret, and respond to published information is an issue of the value of 'Capabilities'; we must stop short of requiring any action from the stakeholder for the value of Transparency per-se. There is also the issue of Timeliness, since publication of information once decisions have been made is also counter to the spirit of the issue. Once again, what constitutes timely is a feature of the content of the publication, and is difficult to

A rule operationalizes Transparency when

- it requires a Decision-Maker to publish or make available information in an accessible manner to stakeholders.
- Such actions must be proactive, and not in response to an action from the stakeholder in question.

With the IG2 syntax:

- [Decision-Maker] (A) {must / shall} (D) {communicate, publish, promote, publicise, solicit feedback, etc.} (I) [Any document or action] (O-D) [To Stakeholders] (EC) OR (O-I)

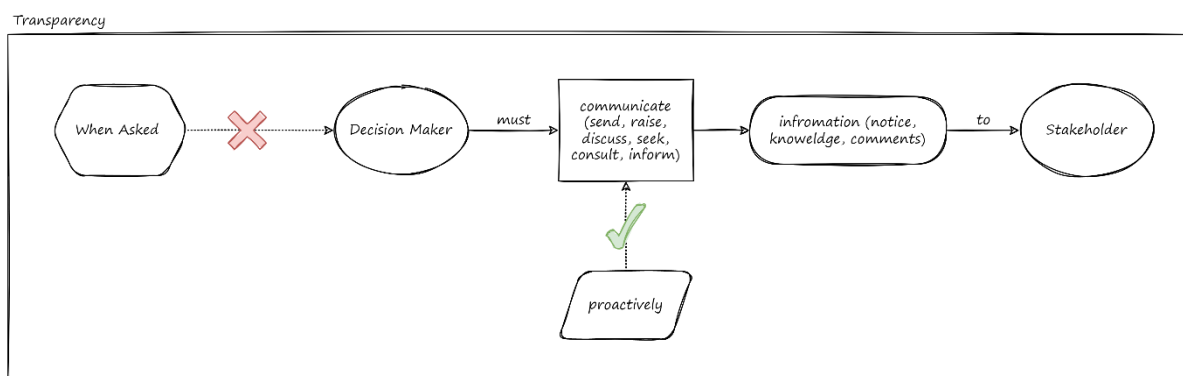


Figure 8 Institutional Diagram Representing Transparency

Accountability: Responsibility for decisions

Accountability is multifaceted and can include social, political, or legal dimensions. For this analysis, we focus on legal accountability directed towards stakeholders. Accountability ensures that decision-makers are held responsible for their actions and that there are mechanisms in place to address grievances and rectify wrongdoings. It establishes a system where power is exercised responsibly and in the interest of the public.

Legal accountability involves clear rules and procedures that define the responsibilities of decision-makers and the consequences of failing to meet these responsibilities. This includes mechanisms for stakeholders to seek redress and for independent bodies to oversee and enforce compliance.

This structure ensures that there are checks and balances in place, with multiple layers of accountability. It enables stakeholders to escalate their concerns and ensures that there are mechanisms to address issues at various levels of authority. By establishing clear lines of accountability, it is possible to ensure that decision-makers act in the best interests of stakeholders and that there are consequences for failing to do so.

- A rule operationalizes Accountability when
- A Decision Maker's action affecting a Stakeholder can be communicated to another Decision Maker,
- The second Decision maker who must take appropriate action. OR
- An explicit sanction exists for the original Decision Maker

This creates a system where decision-makers are answerable to stakeholders and other authorities. This may also take the form of an explicit sanction for the original Decision Maker in the rule.

With the IG2 syntax:

Option 1: Direct Sanctions

- [Decision-Maker 1] (A) {must} (D) {make, execute, implement etc.} (I) {decision, policy, action etc.} (O-D) [Benefitting Stakeholder] (EC), if not [Sanction] (OE)

Option 2: Monitoring

- [Decision-Maker 1] (A) {may / can} (D) {make, execute, implement etc.} (I) {decision, policy, action etc.} (O-D) [Affecting Stakeholder] (EC)
- [Stakeholder] (A) {may / can} (D) {report, notify, inform etc.} (I) {decision, action, policy etc.} (O-D) [To Decision-Maker 2] (O-I)/(EC)
- [Decision-Maker 2] (A) {must / shall} (D) {review, evaluate, sanction, address etc.} (I) {reported decision, policy, action etc.} (O-D) [From Decision-Maker 1] (O-I)/(EC)

Accountability

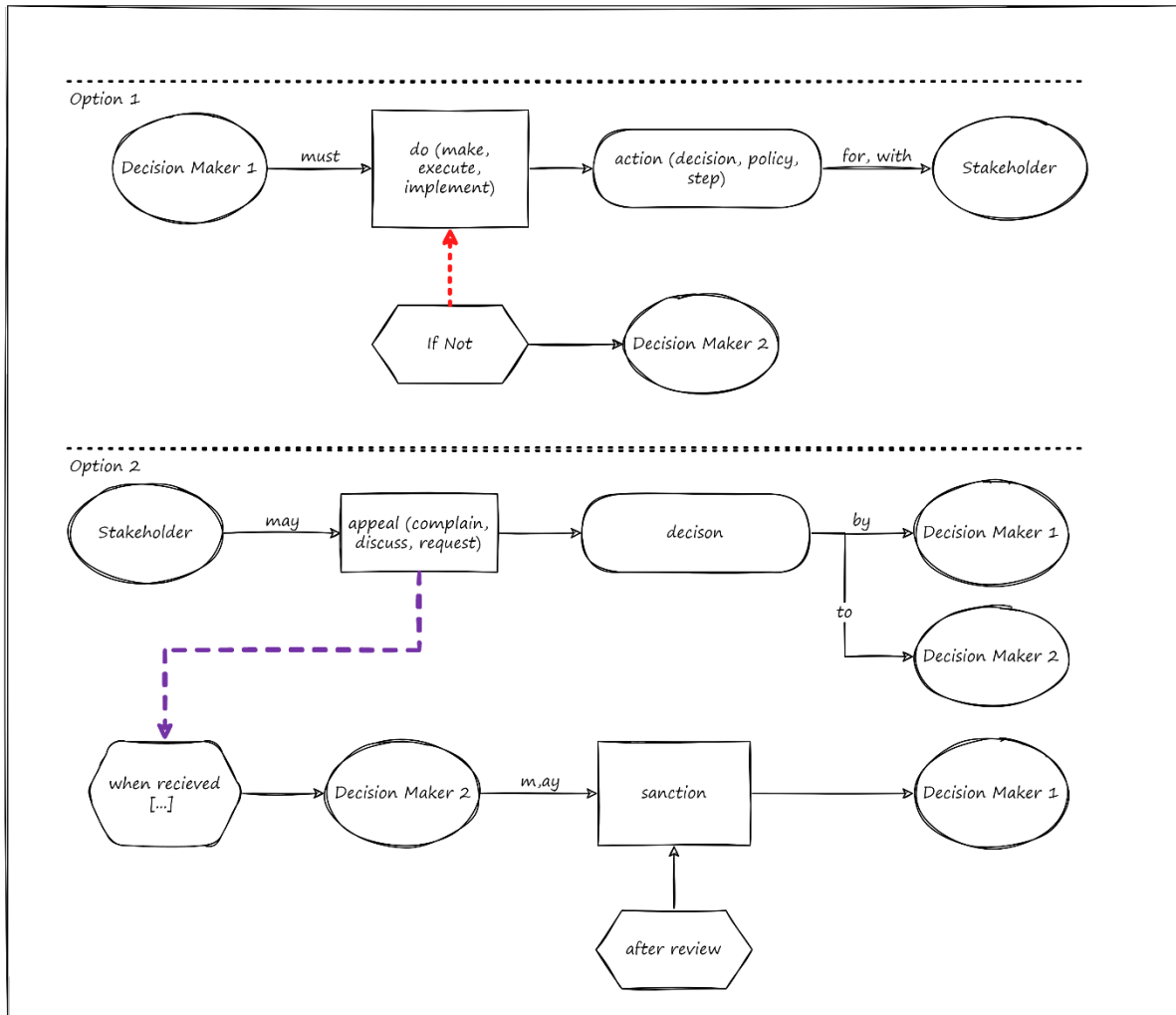


Figure 9 Institutional Diagram Representing Accountability

Correctability: Modification of decisions

Correctability involves the ability to modify decisions. This principle ensures that there are mechanisms to review, amend, or reverse decisions that are found to be flawed or unjust. Correctability is essential for adaptive governance, allowing institutions to learn from mistakes and make necessary adjustments to policies and actions.

Correctability is linked to accountability, primarily because corrections are likely to be initiated by stakeholders. However, rather than duplicating the structure of the accountability provisions, we simply focus on the explicit assignment of both an initial action, and a corrective action to a stakeholder. In this case, the focus is on the anticipation and monitoring of the conditions under which a decision may be corrected.

By embedding correctability into institutional rules, it becomes possible to ensure that decisions are not final and absolute but are subject to review and modification. This fosters a more dynamic and responsive governance system, capable of addressing issues as they arise and improving over time.

- A rule operationalizes correctability when it allows a Decision Maker to take a different action with an object, explicitly to nullify, correct, or modify a previous action, or when such an effect occurs in practice. This principle ensures that decisions can be revisited and revised to better align with justice principles.

With the IG2 syntax:

- [Decision-Maker] (A) {must / may / can} (D) {make, execute, implement etc.} (I) {decision, policy, action etc.} (O-D)
- [Decision-Maker] (A) {must / shall} (D) {nullify, correct, modify, revise etc.} (I) {previous decision, policy, action etc.} (O-D) [When required] (EC)

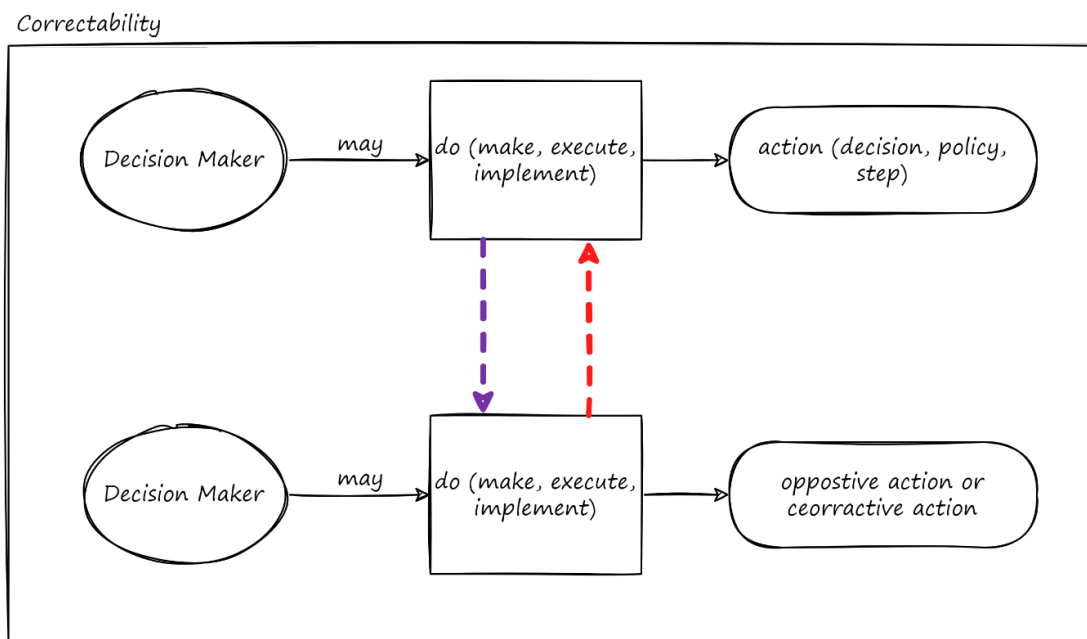


Figure 10 Institutional Diagram Representing Correctability

3.3.3 Application of Framework

The integration of these four principles—Voice, Transparency, Accountability, and Correctability—creates a robust framework for evaluating procedural justice within a system of rules. Each principle addresses a different aspect of justice, ensuring that the decision-making process is inclusive, open, responsible, and adaptable.

When applied to a climate change adaptation case study, this framework can help identify strengths and weaknesses in the procedural justice of the policies and actions involved. By systematically analysing the presence and operationalization of these principles, it becomes possible to make informed recommendations for improving the fairness and inclusivity of climate change adaptation efforts.

The analytical framework presented in this section provides a comprehensive approach to evaluating procedural justice within a system of rules. By defining and operationalizing the principles of Voice, Transparency, Accountability, and Correctability, it is possible to systematically assess the fairness and inclusivity of decision-making processes. This framework is particularly relevant for evaluating climate change adaptation policies, where ensuring procedural justice is essential for achieving equitable and effective outcomes.

By applying this framework to a specific case study, it is possible to identify areas where procedural justice is well-established and areas where improvements are needed. This can inform policy recommendations and guide the development of more just and inclusive climate change adaptation strategies.

3.4 Empirical Analysis of A Procedural Justice Case

The empirical analysis focuses on identifying formal rules in a Climate Change Adaptation setting which influence decision makers toward or away from procedurally just practices. For this analysis, we select an appropriate case study where procedurally just practices may be present, and where gaps in the policy environment have been assessed.

3.4.1 Case Study Selection

The choice of the case study method to investigate procedural justice has been motivated under Research Question 3. The selection of a case study in this analysis is primarily motivated by a desire for descriptive, or exploratory conclusions. Given the hypothesis – that CCA projects may be identified as Procedurally Just through analysis of their institutional characteristics – the following criteria identify an appropriate case-study

1. A well identified climate change adaptation intervention where physical or institutional changes are proposed,
2. The presence of publicly available policy documents in the language of analysis (English),
3. Vulnerable groups affected by the project are identified in the project literature or by project parties
4. (Preferably) Evaluation of existing social and legal environment to determine and assess applicable laws, and policies.

Additionally, pragmatic, and logistical issues of access and familiarity also play an important role in selection of a case study. Based on the guidance contained in Seawright and Gerring (2008) and Becker and Ragin (1992), a purpose selection of case study to establish a ‘typical case’ has been chosen.

The World Bank, Procedural Justice in Social Risk Assessment

International Development Organisations (IDOs) are among the major mechanisms through which state-sanctioned adaptation programs are funded (S. D. Donner et al., 2016). In accordance with their mandates and obligation to the international community, many of these IDOs have highly structured reporting obligations, and processes of disclosure for project related documents.

The World Bank is an IDO with a significant commitment to funding CCA related projects and has historically funded a mix of ‘hard’ and ‘soft’ adaptive interventions. As of 2024, the World Bank has over 1800 active project under the theme of ‘Climate Change Adaptation’. Any of these projects is likely to provide a window into the forefront of current climate change adaptation efforts.

Additionally, World Bank has an extensive system of Environmental and Social Safeguards (ESS) (World Bank, 2018a, 2018b). These are internal policies designed to ensure that the projects they finance do not harm people or the environment. They require proactive and ongoing disclosure from project Implementing Agencies, ensuring that requirements for equitable social and economic distribution of costs and benefits. These safeguards require projects to identify and manage risks, promote transparency, and engage stakeholders through public consultations. By implementing these safeguards, projects must disclose relevant social risks and applicable laws, ensuring comprehensive oversight and accountability.

The Environment and Social Impact Assessment is one such disclosure that is made for all Climate linked projects . This report includes a joint evaluation conducted by the Bank and the Implementing agency on the governance environment affecting the project, as well as a classification of social and environmental risk. The Bank supports this assessment with recommendations and safeguards intended to mitigate this risk. This assessment may form the backbone of the case study, and used to identify the specific regulations that are considered applicable to the project. The assessment also identifies specific documents (legislative, legal, and policy) that contain institutions perceived to be relevant.

Studying one of these projects offers valuable insights into the practical application of procedural justice in climate adaptation efforts.

Case Study: Chennai City Partnership

The chosen case study for this research is a World Bank-funded project in Chennai, India. Chennai, the capital of Tamil Nadu, is located along the Coromandel Coast, adjacent to the Bay of Bengal, making it highly susceptible to seasonal monsoonal and cyclonic events. The city's larger metropolitan region is planned by the Chennai Metropolitan Development Authority and spans over 1800 sq km (Greater Chennai Corporation (GCC), 2021). The city's susceptibility to flooding is further exacerbated by urban sprawl, notably the encroachment upon and the transformation of natural wetlands into built-up areas. The socio-economic context of Chennai, characterized by rapid urbanization and significant socio-economic disparities, provides a rich backdrop for studying the impacts of climate adaptation policies.

The Chennai City Partnership: Sustainable Urban Services Program (P175221) is a World Bank initiative designed to improve urban services in the Chennai Metropolitan Area (CMA) (World Bank, 2022). The program aims to enhance the quality, sustainability, and resilience of essential services such as water supply, wastewater management, urban mobility, solid waste management, public health, and disaster response. With a budget of USD 1.43 billion, the program focuses on strengthening institutions, infrastructure development, and expanding financing mechanisms. The project is expected to run from 2021 to 2030 and includes significant investments in integrated water resource management and urban mobility to address the needs of the growing urban population and improve overall service delivery.

Given the scale of the program, the analysis will focus on only 1 of the four sectors in which the intervention is planned have been selected for the analysis. Program component 1.2 under the program is 'Sewer Network in 5 underserved communities' and provides for construction of

underground sewer system piping and providing sewer connections to households. This component was assigned a ‘Moderate’ social risk rating, owing to the potential for livelihood disruptions, lack of stakeholder engagement, and systemically poor occupational health and safety for sewage workers.

3.4.2 Analysis Scope

The objective of the case study is to evaluate the procedural justice of the proposed Climate Change Intervention, given the institutional environment in which the intervention is being implemented. This restricts the scope in a few ways.

First, the identification of the intervention, its technical character, and its appropriateness for the hazards it claims to address is not directly addressed by the analysis. It is important to assume that claims made about the project are on good faith and assumed to be justified.

Second, groups self-identifying as impacted by the project, or identified by others as impacted by the project must be included as part of the analysis. This precludes any direct investigation of the merit of any claims of impacts, and similarly assumes those claims are made on good faith and justified.

Further, since the objective is to isolate the impact of institutional arrangements on procedural justice ex-ante, we restrict the analysis to the adherence to the principles themselves. Thus, it is irrelevant to the analysis whether project outcomes are distributionally just. Similarly, efforts to compensate groups to correct or compensate for policy failures, legal or political action taken by groups to protect their rights or to solicit interventions are all irrelevant to the adherence to justice principles, unless explicitly invoked by the policy documents to be studied.

4 Approach and Methodology

4.1 Research Design

The research design of this study is bifurcated into two primary tracks, each addressing distinct yet complementary objectives. The first track, focuses on developing an understanding of procedural justice in climate change adaptation projects, using the institutional analysis methodology. In this track, the emphasis is on generating knowledge around how institutions may be made more procedurally just. The second track is focused on investigating the possibility of creating and refinement of a system designed for the automated extraction of Institutional Grammar (IG) coded policy statements from various policy documents. This track is crucial in reducing the manual effort typically involved in the annotation process, thereby increasing the efficiency and scalability of the analysis. The second track provides a tool through which the analysis in the first track is able to investigate complex Climate Change Adaptation (CCA) projects. Figure 11 in the thesis illustrates these two tracks and their interconnections.

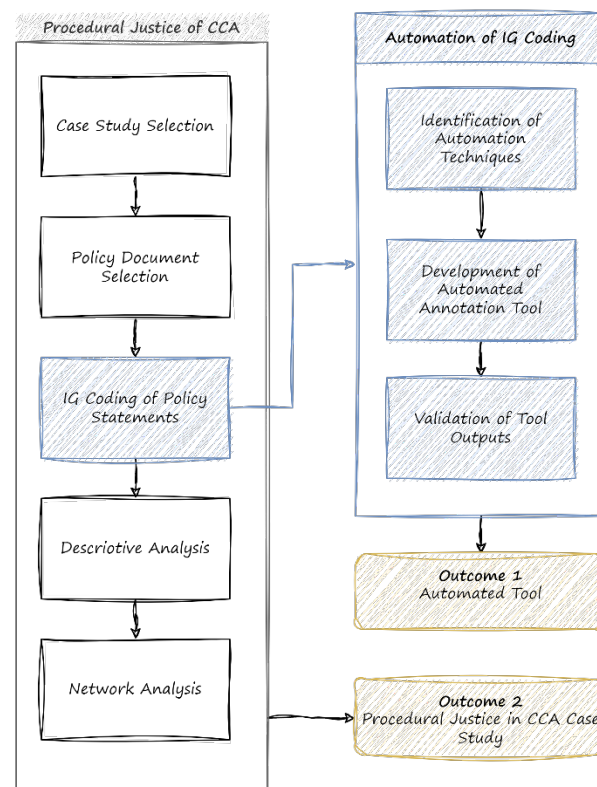


Figure 11 Research Flow

4.1.1 Methods of Identifying Procedural Justice in CCA

In Section 3.3, I identified several dimensions of procedural justice that are particularly relevant to the institutional environments of Climate Change Adaptation Projects. These dimensions are essential for ensuring that the processes involved in CCA projects are fair and inclusive. This section outlines the detailed steps involved in the analysis of procedural justice within CCA projects. These steps are as follows:

1. Selecting a Case study
2. Identification of Relevant Policy Documents
3. Coding documents to Identify Institutional Statements and their components
4. Descriptive analysis of IG syntax components in policy statements
5. Identification of policy statements relevant to procedural justice

Selecting a Case Study

This involves choosing a specific CCA project that provides a suitable context for the analysis. The selection criteria include the project's relevance to climate change adaptation, the availability of comprehensive policy documents, and the presence of identifiable vulnerable groups impacted by the project. The case study must be representative of the broader issues in climate change adaptation, ensuring that the findings can be generalized to other similar projects. Factors such as the project's geographical location, socio-economic context, and the scale of the adaptation efforts are also considered. The selected case study should have well-documented processes and outcomes, allowing for a thorough investigation of procedural justice elements. The methods to identify relevant projects, and the actual selected project have been reported under Chapter 3.4.

Identification of Relevant Policy Documents

Once a case study is selected, the next step involves identifying and collecting all relevant policy documents that govern the project. These documents are the primary sources for the subsequent coding and analysis processes. The documents may include national and local laws, regulations, policy guidelines, project reports, and any other relevant official communications. The goal is to gather a comprehensive set of documents that provide a complete picture of the institutional environment in which the CCA project operates. This step is critical because the quality and completeness of the policy documents directly impact the accuracy and depth of the analysis. The selected documents are reported here along with the case study in Chapter 3.4

Coding Documents to Identify Institutional Statements and Their Components

This step typically involves manually tagging the policy documents to identify specific institutional statements and their components using the Institutional Grammar framework. Institutional Grammar (IG) provides a structured way to break down complex policy statements into their constituent parts, such as attributes, deontic, aims, objects, conditions, and sanctions. Each component is analysed to understand its role in the broader institutional context. The manual coding process involves detailed reading and interpretation of the policy documents, followed by the systematic application of IG coding rules. This ensures that all relevant statements are accurately captured and coded, providing a solid foundation for subsequent analysis. It is typically labour intensive and may be subject to errors and biases from individual researchers. The manual coding protocol is reported in Chapter 4.2, as a foundation of automated processes proposed in Chapter 5.

Descriptive Analysis of IG Syntax Components in Policy Statements

The coded data are analysed to identify the various IG syntax components present in the policy statements. This analysis provides insights into the structure and content of the institutional statements. By examining the frequency and distribution of different IG components, researchers can identify patterns and trends in how procedural justice is addressed in the policy documents. This step involves both qualitative and quantitative analysis techniques, including statistical analysis and thematic coding. The results of this analysis help to highlight the key aspects of procedural justice that are emphasized in the policy documents and identify any gaps or inconsistencies. (Olivier, 2019)

Identification of Policy Statements Relevant to Procedural Justice

The final step in this track involves identifying policy statements that are specifically relevant to procedural justice. These statements are crucial for understanding how procedural justice is addressed in the CCA project. In Chapter 3.3, we established 4 dimensions of procedural justice that it may be possible to independently assess in the institutional statements.

By focusing on statements that embody mention principles of voice, transparency, accountability, correctability, it is possible to infer whether these statements are likely to benefit vulnerable project affected groups. This step involves a detailed review of the coded data, identifying and categorizing statements based on their relevance to procedural justice. Specific criteria for each justice dimension are identified in Chapter 3.3. The findings from this

step provide a clear picture of how well the CCA project aligns with established principles of procedural justice.

4.1.2 Automated Annotation Software Development

Manual tagging of IG-coded institutional statements, while effective, is both cumbersome and time-consuming. It also limits the ability to analyse a broad set of institutional statements, which is necessary for comprehensive research. To address these limitations, this research proposes the development of a novel tool-assisted coding approach (Chen et al., 2023). Existing general-purpose coding tools, however, are not well-suited for the specific task of identifying IG syntax. Likewise, existing special-purpose tools for IG syntax tagging do not adequately address the unique requirements of this research.

To overcome these challenges, it is necessary to develop a custom tool specifically designed for the automation of institutional statement annotation. Recent advances in Natural Language Processing (NLP) using Large Language Models (LLMs) provide new opportunities for the structured tagging of institutional statements. This part of the research aims to develop and validate a tool that leverages these LLMs for the automated tagging of institutional statements. The detailed method for developing and validating this tool consists of the following steps:

1. Selection of LLM Design Approach
2. Development of Automated Annotation Software
3. Validation of Automated Annotation Output performance

Selection of LLM Design Approach

The first step involves selecting an appropriate LLM design approach that can effectively overcome the complexities of institutional statement annotation. This includes choosing the right model architecture, adopting a strategy for learning and fine-tuning. The design approach must ensure that the LLM can understand and accurately annotate the diverse and nuanced policy statements found in CCA documents. Various LLM architectures, such as transformer-based models, are considered for their ability to process substantial amounts of text data and capture intricate language patterns. The limited availability of tagged training data is another constraint that must be designed for.

Development of Automated Annotation Software

Once the design approach is selected, the next step is to develop the software that will use the LLM to automate the annotation process. While a comprehensive GUI is outside the scope of

this project, a series of modular interfaces to manage complexity are necessary. This involves integrating a framework that can be used to rapidly evaluate and iterate as new models and techniques continue to become available. It also requires a software architecture to preprocess documents, select chunks for annotation, and manage the model outputs.

The details of the software architecture are available in Section 5.3

Validation of Automated Annotation Output Performance

The last step involves validating the performance of the automated annotation tool. This is done by comparing the tool's output with a benchmark set of human-coded statements. Metrics such as accuracy, precision, recall, and F1 score are used to evaluate the tool's performance. The validation process requires compromise against a benchmark dataset of policy documents annotated by human experts. This dataset serves as the gold standard for evaluating the tool's performance. Performance metrics are needed to evaluate the models' performance and demonstrate the tool's accuracy and consistency.

Finally, we conduct a qualitative analysis of the errors produced by the tool. This provides insight into next steps and potential pitfalls in edge cases.

Upon successful validation, the tool can be reliably used for the analysis of the case study. The research outputs from this approach include, first, a validated software tool for automated annotation that can be used for IAD research, and second, an exploratory analysis of the CCA case study focusing on the identification of procedurally just institutions.

4.2 IG Coding Methodology

4.2.1 IG Coding Schema

In this chapter, I provide an outline of the process a human expert would follow when coding policy documents for institutional content. 'Coding' in this context refers to the structured annotation of document content to infer structure, meaning, and intent in a reproducible and traceable manner (□). For this study, I use the IG 2.0 Core Coding Schema, and attempt to align with the coding protocol suggested for it.

The Institutional Grammar 2.0 (IG2.0) framework is a refined tool for encoding policy documents and institutional statements, building on the foundational work of Crawford and Ostrom (1995). This version enhances the granularity and specificity of the original Institutional

Grammar, making it suitable for detailed analytical objectives, including statistical assessments and computational applications (Frantz & Siddiki, 2022).

IG 2.0 Core

The coding schema of IG2.0 Core is designed to systematically break down institutional statements into analysable parts. The IG2 Core distinguished between two types of statements – Constitutive and Regulative. Constitutive statements are a special kind of statement that consists of assigning or endowing entities with positions, attributes, or other ‘institutional’ properties. Regulative statements are more typical statements that concern the regulation of behaviour and actions. In this study, only regulative statements are considered as a part of the scope of this analysis. This does not limit the applicability of the study since constitutive statements can be expressed in regulative syntax.

The key components of the schema include:

- Attribute (A): Denotes the actors or entities involved in the statement.
- Object (B): The entity or entities upon which actions are performed.
- Deontic (D): The modal verbs indicating obligation, permission, or prohibition.
- Aim (I): Specifies the intended outcome or action.
- Context (C): The conditions or constraints under which the statement is valid. The context is further subdivided into two components.
 - o Activation Condition: This controls when an action applied and when it must be initiated or performed.
 - o Execution Constraint: Information regarding how an action should be performed is encoded in this climate component.
- Or else (O): The consequences of non-compliance with the statement.

These components enable a detailed and structured analysis of institutional statements, facilitating a more nuanced understanding and comparison of policies across different contexts (Frantz & Siddiki, 2022).

Why IG 2.0 Core is Selected

IG Core is chosen for this research, and has been preferred over both the original syntax proposed by Ostrom, as well as more expressive syntax such as the IG Extended and Logico. The specificity of the IG Core, particularly in the articulation of the various types of statement context, provides a superior foundational structure without the complexity of higher levels of expressiveness like IG Extended or IG Logico. This balance between comprehensiveness and

simplicity is particularly useful for initial analysis, enabling straightforward comparisons across different institutional settings or over time, and ensuring computational efficiency by organizing data in a manner that is easily adaptable for computational models and statistical analyses (Frantz & Siddiki, 2022).

4.2.2 Steps for Coding with IG2.0 Core

The process of coding a document using IG2.0 Core involves 5 steps.

1. Familiarization with the Institutional Setting
2. Selection of Coding Platform
3. Preprocessing of Institutional Information
4. Annotation of Institutions
5. Validation and Review

Familiarization with the Institutional Setting

Familiarization refers to an initial overview of a legal document or policy to be coded. The coder must understand the context, significant actors, actions, and relationships within the document. It generally consists of reading the policy document, and understanding the organisation of information, as well as any significant external dependencies that help explain the document's significance, overall applicability and the intended outcomes. It is also helpful to understand the authorship and ownership of a document to understand if it is innately prescriptive, aspirational, or instructional. This preparatory work lays the foundation for accurate and consistent coding in subsequent steps.

Selection of Coding Platform

Once the institutional context is understood, the next step is the selection of a coding platform. The platform chosen should be capable of storing and organizing the coded data, accommodating the complexity of the institutional statements, and meeting the intended analytical use. In this project, final institutional information is reported through spreadsheets and associated software. This is to simplify the sharing, comparison, and storage of policy content. The limited volume of data, and limited complexity of the final code are also motivators. coding task, and the specific needs of the research.

Initial Organization of Institutional Information

It is important to eliminate redundant information and details from the policy documents to minimise the cognitive (or computational) load in later steps of the coding process. This can

take many forms, depending on the nature of the document, but in the cases identified consists of eliminating tables, equations, or other calculations that only feed numerical information to policy statements. These may also contain information such as phone numbers, addresses, and names of appointees that are in principle dynamically assigned through the exercise of institutional actions.

Another action that is necessary is to ‘compose’ statements from nested lists and hierarchies. For instance, an institutional statement may be written as, ‘ROLE will perform the following actions: (a) ... (b) ... (c) ...’ This statement would best be composed as 3 independent statements of the form ‘ROLE will perform the following actions: (a)’, ‘ROLE will perform the following actions: (b)’, and so on. Such ‘composition’ helps pair statements with the necessary context, and reduces the likelihood of losing information.

Once this has been done, passages may be ‘cleaned’ – omitting punctuation, numbering, bullets and parenthetical statements that no longer carry information.

This organization helps in systematically approaching the coding task and ensures that no relevant information is overlooked. It also aids in maintaining consistency throughout the coding process. By having a clear structure in place, the coder can easily navigate the document and apply the coding schema accurately.

Coding Process

Once the coder has determined the passages that contain institutional information of interest, the act of coding institutional statements may proceed. For each passage, the coder must first decompose the text into ‘Atomic’ institutional statements. Frantz and Siddiki offer extensive guidance for this, which I will not reproduce. However, the essential characteristics of an ‘Atomic Statement’ are as follows:

1. It contains a unique and identifiable Aim
2. It contains a single Attribute, whether identified or inferred
3. Other components, if present, must be singular.
4. Statements must be in the active voice, if possible.

A complex passage or statement will decompose into several atomic statements. These atomic statements are then well prepared for the clear identification of components. The decomposed statements and the identified or inferred components are then saved.

Consistency and Validation

After the coding is completed, a validation and review phase are conducted. This step involves a thorough review of the coded data to confirm its accuracy and reliability. Cross-referencing with the original document and consulting with other coders, if necessary, helps ensure the consistency and validity of the coding. Often, multiple policy coders work together to code documents, with the multiple coders ensuring some redundancy and overlap to compare their results and ensure reliable and comparable outputs. In the context of this study, however, such systematic protocol has not been possible.

Coding with IG2.0 Core provides a structured and efficient method for analysing institutional statements. By focusing on essential components, it facilitates clear and comparative analysis.

4.3 Data Collection

4.3.1 Policy Documents as Data

The selection of policy documents from the Chennai Case Study is based on the Environmental and Social Systems Assessment conducted by the World Bank. The ESSA for the Chennai City Partnership: Sustainable Urban Services Program was conducted in accordance with the World Bank Policy Program-for-Results Financing (PforR Policy). This methodology leverages country-level systems for managing environmental and social risks and impacts, ensuring consistency with six core environmental and social principles, which include promoting sustainability, protecting public and worker safety, managing land acquisition impacts, and considering the cultural appropriateness and equitable access to program benefits.

The assessment is conducted by Bank selected experts to evaluate the environmental and social impacts of proposed programs. They evaluate both the material likelihood of risks, as well as the institutional and managerial systems used by implementing agencies to mitigate those risk.

This methodology includes a thorough desk review of existing policies, and published procedures relevant to the program activities. This is generally followed by direct consultations with agencies, and stakeholder consultations. While the list of documents reviewed and the final assessment reports are made publicly available, in most cases the transcripts of discussions with IAs are not. The final assessment is in two parts, first, stating the adequacy of the legal and policy framework; and second, stating the management capacity of the

implementing agency to meet the standards in that framework. The scope of this institutional assessment is to attempt a reproduction of the first part of this analysis.

The policy documents included in the World Bank Social Systems Assessment for the Sewage system project component are as follows:

- The Chennai Metropolitan Water Supply and Sewerage Act, 1978
- Citizen Charter of CMWSSB
- Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act 2013
- The Tamil Nadu Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Rules, 2017
- Street Vendors (Protection of Livelihood And Regulation of Street Vending Act) 2014
- Tamil Nadu Street Vendors Rules 2015
- Tamil Nadu Land Encroachment Act, 1905
- National Urban Sanitation Policy, 2008
- Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013

Of these, Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act 2013, Right to fair compensation act 2017, and the Land Encroachment Act 1905 were excluded from the scope of the World Bank study, because no land acquisition was planned as part of the project screening. Similarly, the National Urban Sanitation Policy was excluded from the analysis because it is not binding to any of the agencies involved in the project.

Additionally, it is necessary to define what groups are likely to be impacted by the project and what justice implications exist for them. The ESSA identifies the following group at risk.

- End Users
- Urban Poor and Minority Groups
- Construction Labour
- Sanitation Workers
- Up-stream and Down-stream water users

The main types of negative social impact from the project are:

- Prohibitively expensive wastewater connections

- Ineffective Grievance Redressal in availability and quality of service in connected wastewater
- Loss of livelihood from construction impacts
- Temporary displacement due to construction
- Labour issues due to poor contractor management and labour standards enforcement
- Occupational health and safety issues in infrastructure operation
- Continued risk of manual scavenging and intergenerational exploitation of sanitation workers
- Ineffective ICC and handling of sexual harassment claims among workers
- Ineffective management of treated sludge and wastewater disposal
- Ineffective grievance redressal for communities at disposal sites.

4.3.2 Wastewater Systems – Action Arenas and Justice Concerns

Wastewater infrastructure projects are complex, multi-phase endeavours that involve a wide array of stakeholders and have far-reaching social, economic, and environmental implications. To fully understand the procedural justice considerations in such projects, it is essential to examine each phase of the project lifecycle and identify the key stakeholders involved, the technical actions undertaken, and the potential impacts on vulnerable groups.

The project lifecycle of a typical wastewater system can be divided into five distinct phases: design, construction, commissioning, operation, and decommissioning (World Bank, 2020). Each of these phases presents unique challenges and opportunities for ensuring procedural justice and equitable outcomes.

Design Phase

The design phase is critical for setting the foundation for a just and inclusive wastewater system. This phase involves the conceptualization and planning of the infrastructure, including site assessment, feasibility studies, and the development of detailed engineering designs. The primary decision-makers in this phase include engineers, architects, urban planners, and local government officials who are responsible for ensuring that the project design is technically sound, financially viable, and socially acceptable (Brelsford et al., 2020).

Wastewater projects may be initiated due to a need to expand services to newly urbanised areas, improvement in level of service in existing areas, or the need to rehabilitate or replace aging infrastructure. They may also be motivated by a need to improve treated effluent quality and meet improved environmental standards. The selection of an area for installation of

sewage, the siting of 'unsightly' infrastructure like pumping stations and treatment systems, and even the process of estimating demand are all decisions involved significant exercise of judgement (Keeney et al., 1996). These may result in inequitable outcomes and benefits, such as through impacts on land prices, or on livelihoods.

Participation in the design phase of projects is often restricted to those perceived as 'technical experts' or 'decision makers'. Often, maintenance workers, street level bureaucrats, and other community representatives have limited input and visibility on the design process (Gomez & Nakat, 2002). This leads to compounding uncertainties, which may manifest in later project stages.

Construction

The construction phase marks the physical realization of the project design and involves a range of technical actions such as excavation, laying of sewer pipes, construction of treatment facilities, and installation of pumping stations (World Bank, 2020). The primary decision-makers in this phase include the implementing agency, contractors, suppliers, and engineers who are responsible for executing the project according to the design specifications and within the allocated budget and timeline.

However, the construction phase also poses significant risks for procedural injustice, particularly in terms of occupational health and safety. In India, construction workers, particularly those from marginalized communities, often lack access to proper safety equipment, training, and medical care, making them highly vulnerable to accidents and health hazards (Baradi et al., 2021). Therefore, it is crucial that the project implementation includes strict protocols for ensuring worker safety, providing adequate protective gear, and offering regular health check-ups and medical support.

In this phase, there may also be significant negative externalities to groups such as road-users, vendors and businesses who are affected by the installation of lines.

Commissioning

The commissioning phase involves testing and verifying the functionality and performance of the constructed wastewater system. In many cases, this is also when household and businesses are required to connect to the infrastructure service. There may be a compulsion to connect to the service, as well as fixed charges associated with the connection. This phase also includes technical actions such as system testing, performance monitoring, and quality assurance (Aziz, 2013). The primary decision-makers in this phase include engineers,

technicians, and local government officials who are responsible for ensuring that the system meets the required standards for effluent quality, environmental protection, and public health (Limaye & Welsien, 2019).

However, the commissioning phase also presents opportunities for enhancing procedural justice by involving the local community in the testing and verification process. By engaging with the users of the wastewater system, the project implementers can gather valuable feedback on the system's performance, identify any issues or concerns, and make necessary adjustments to ensure that the system meets the needs and expectations of the community.

Operations

The operation phase is the longest and most critical phase of the wastewater project lifecycle, as it involves the day-to-day running and maintenance of the system. This phase includes technical actions such as wastewater collection, treatment, and disposal, as well as regular maintenance and repairs. The decision-makers in this phase include the wastewater utility operators, maintenance staff, and local government officials who are responsible for ensuring the smooth and efficient functioning of the system (Corominas et al., 2018).

The operation phase of wastewater systems presents some of the highest significant risks for procedural injustice, particularly in terms of the working conditions and safety of the sanitation workers. In India, the cleaning and maintenance of sewer systems is often conducted by manual scavengers, who are forced to enter the sewers without proper protective gear and are exposed to toxic gases and pathogens. This practice is not only a gross violation of human rights but also perpetuates the cycle of caste-based discrimination and social exclusion (Du et al., 2021).

The issue of poor occupational safety for these workers is endemic and has led to the introduction of legal provisions to compare implementing agencies toward enforcing strict protocols for mechanized cleaning, provision of proper safety equipment, and regular health check-ups for all sanitation workers. However, it is often unclear to what extent these provisions are incorporated or made available to workers.

Operation also poses significant risks for populations downstream from projects. In coastal cities like Chennai, this may be fishers or other coast users who might experience pollution if treated effluent affects natural systems.

Decommissioning

The decommissioning phase involves the closure and dismantling of the wastewater infrastructure at the end of its useful life. This phase includes technical actions such as the removal of equipment, demolition of structures, and site remediation. The decision-makers in this phase would be infrastructure owners and contractors, environmental consultants, and local government officials who are responsible for ensuring that the site is properly closed and remediated.

In conclusion, wastewater infrastructure projects involve multiple phases, each with its own set of technical actions, stakeholders, and potential impacts. In the Indian context, the issues of manual scavenging, hazardous working conditions, and livelihood disruption for marginalized communities are particularly pressing concerns that need to be addressed through a procedurally just approach.

Furthermore, it is crucial to recognize that procedural justice in wastewater projects is not only a matter of technical design and implementation but also a fundamental issue of human rights, social equity, and environmental sustainability.

This taxonomy of project phases will be used further in the analysis in Chapter 6 as the Action Arenas of interest from an institutional justice perspective. The decision makers and vulnerable groups outlined here will be incorporated in the framework from Chapter 3.3.

5 Method of Automated Annotation

5.1 Background

As discussed in the previous chapters, the overall objective of this research is to understand the influence of institutional structures on the achievement of procedural justice in climate change adaptation (CCA) policy. This analysis requires the annotation of public policy documents with the ‘Institutional Grammar’ – a methodological approach that has proven to be a versatile tool in extracting meaning from text data. Given the volume and complexity of the documents, an automated approach, where a human policy analyst oversees a machine-coding system, would significantly reduce the resources and time required for the analysis.

This chapter presents a design, pilot implementation, and benchmark for such a system. The proposed ‘IG-Annotator’ builds on previous work in this area, by incorporating latest advances in Machine Learning in the form of Instruction-tuned Large Language Models (Brown et al., 2020).

The application of a new tool towards extracting data, brings with it some epistemic and engineering challenges. First, the performance of the Language models needs to be compared to human annotators and validated. Second, building a tool that can leverage this knowledge and be applied to an analysis task with sufficient confidence.

5.2 The Annotation Task

First, I need to construct a model of how machine learning may be applied to the annotation task. The process for coding in this project consists of 4 elements. Here, each step is explained in the context of annotating a text with the syntax of the Institutional Grammar.

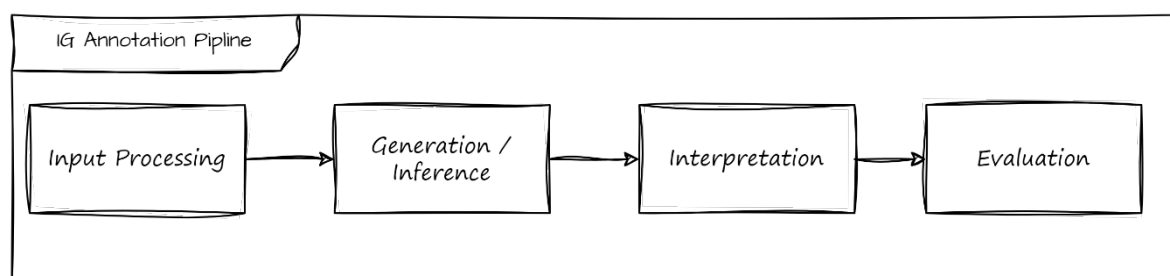


Figure 12 IG Annotation Pipeline

Input Processing: Turning a dataset or document into a standard format suitable for machine annotation. This includes standard NLP steps such as cleaning and tokenisation; it may also involve adding information, such as inserting context, metadata, or labelling token attributes.

Generation / Inference: The core task. Previous attempts have used Natural Language Processing tools, such as POS or SLR annotations, and built inference models that predict labels based on the underlying token and its annotation. A large language model would receive text as input, and producing some output based on the underlying model, it's training information, and the task(s) assigned to it through prompting or finetuning instructions.

Interpretation: Large Language Models are stochastic and cannot guarantee consistent outputs. The outputs of the model need to be cleaned and formatted to align and ingest it into a structured format. Strategies for interpreting and aligning outputs can vary based on the desired structure of the program.

Evaluation: To find the most effective strategies, metrics that can assess the quality of the final products are necessary. Two primary evaluation strategies are possible for this use case: human directly scoring the output of the model; or comparing model output to a human evaluated gold standard. For this use case, the second approach has been selected.

Each of the elements in the pipeline has several epistemic and engineering challenges. The engineering objectives and research questions associated with implementing this as a software system are outlined below:

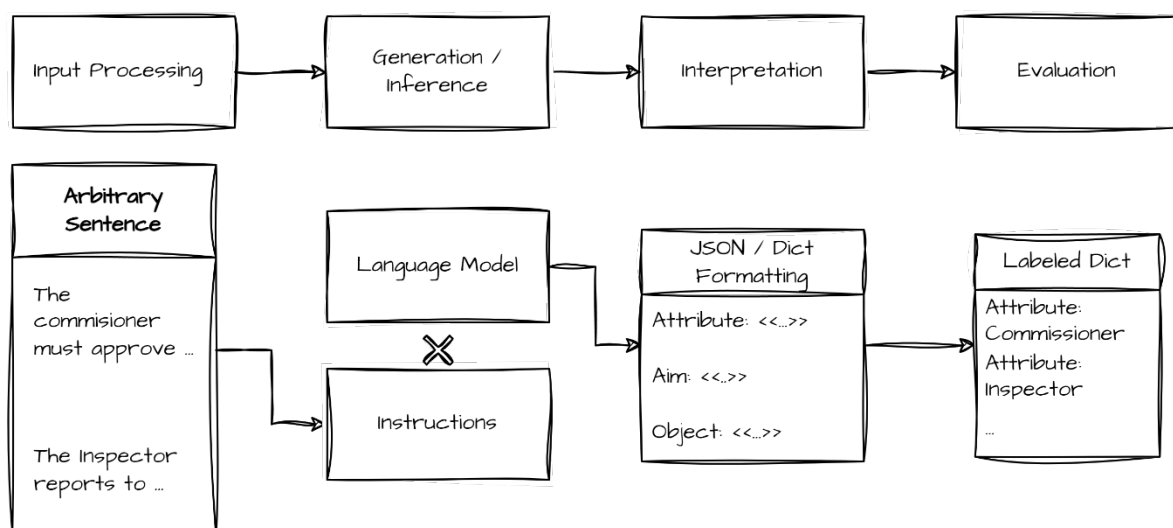


Figure 13 Epistemic and engineering challenges

5.3 Large Language Models and their applications

The public release of ChatGPT in December 2022 marked a tectonic shift in public awareness of Generative AI, and Large Language Models. Public availability of the tool has triggered interest in potential applications across industries. This increase in interest has been possible due to two critical innovations – the ‘transformer architecture’ and ‘instruct tuning.’ These advancements rely on several massive publicly available datasets, as well as existing work such as vector embeddings and retrieval mechanisms (Touvron et al., 2023).

5.3.1 Transformer Models: The Backbone of LLMs

Transformers, introduced by Vaswani et al. in 2017, revolutionized NLP by addressing the limitations of recurrent neural networks (RNNs) and long short-term memory networks (LSTMs). The transformer architecture consists of first, a vector embedding. The LLM consists of a dictionary where words are represented as multi-dimensional vectors based on an initial understanding of their ‘meaning.’ These vectors are then transformed through the self-attention mechanism. This mechanism is used to update vectors in a sequence by transforming them using the weights of other tokens in the sequence.

This architecture allows text that is not immediately adjacent in the string to still influence word representation, thereby capturing long-range dependencies and contextual information more effectively. Transformers also employ multi-head attention, which allows the model to focus on parts of the sentence simultaneously. Each head independently applies the self-attention mechanism, and the results are concatenated and linearly transformed to capture diverse aspects of the context.

These updated representations become inputs for the final ‘inference head’ of the model. This is a specialised unit that processes the previous inputs and attempts to convert that to a satisfying output. A common task, such as that used for GPT – is simply predicting the next word in a sequence. By doing so, the model can iteratively construct words, and generate a complete text in response to a provided input.

There are 3 types of transformers that are used frequently for text tasks.

Encoder-only transformers, such as BERT, are specialised in turning sequences of texts into reduced units of information. They excel at tasks such as sentiment analysis or named entity recognition (Wu et al., 2023). These models are designed to convert input sequences to abstract numerical representations. They excel in tasks that require comprehending text, like sentence classification and token classification. The encoder processes the input data,

building a representation that captures contextual information, which is then used for tasks like.

Decoder-only transformers, exemplified by GPT models, are designed for generative tasks. They predict the next token in a sequence based on the previously generated tokens, making them ideal for text generation and completion tasks. These models have been theoretically shown to be Turing complete, meaning they can simulate any computation given sufficient resources (Yang et al., 2023).

Encoder-decoder transformers, like the original Transformer model and BART, are used for sequence-to-sequence tasks. The encoder processes the input sequence to produce a context-rich representation, which the decoder then uses to generate the output sequence. This architecture is effective for tasks like machine translation, summarization, and data-to-text generation, as it combines the strengths of both encoding and decoding contexts (Nie et al., 2017).

5.3.2 Pretraining, Finetuning, Learning

The transformer architecture thus divides the task of interpreting and representing inputs, and the task of selecting a response into separate tasks. Thus, the model weights trained for a particular task, or on a model general corpus may be leveraged with little effort later on. These steps are commonly referred to as ‘Pretraining’ and ‘Finetuning’.

Pretraining is performed on a vast amount of text data, allowing it to learn general language patterns, representations, and structures. Common tasks for pre-training include the text generation task. Through this, the pretrained models acquire broad ‘knowledge’ of language representations and associations between words. For instance, the study "Pre-training Language Models for Comparative Reasoning" shows that pretraining improves the comparative reasoning abilities of language models, especially under low-resource conditions.

Fine-tuning, also called transfer learning, refers to the process of adapting a model to a specific task. In many cases, finetuning consists of adapting the model ‘inference head’ to produce responses better suited for a particular task (Han et al., 2023). Finetuning has been used extensively by authors to perform specialised tasks. Zhou et al. leveraged BERT’s fine tuning capabilities to produce a semantic-parser capable of performing 5 different NLP tasks, including POS tagging and SRL (H. Zhou et al., 2022). However, most fine-tuning approaches are limited by the availability of substantial datasets for the training process.

Few-Shot and Zero Shot learning.

Brown et al (2020) showed that large language models demonstrate the ability to perform NLP tasks from simple instructions or few examples. This capability of LLMs has come to be called few-shot or zero-shot learning (where zero refers to the number of example tasks provided). Since then, ‘instruct-tuning’ has become a normal part of LLM training. This is a fine-tuning step, conducted in concert with pre-training, where models are provided with several instruction following tasks from different domains, including question answering, annotation, or parsing.

Zero-shot learning is also called ‘in-context learning’ because the model is ‘learning’ from the content provided to it as an input or ‘in-context.’ Similarly, it is also called ‘prompt engineering’ since the user is crafting ‘prompts’ or ‘inputs’ to shape the model’s outputs.

zero-shot learning is used for this project.

5.3.3 Measuring LLM performance

There are numerous techniques available to benchmark LLM performance, ranging from human raters directly giving feedback on LLM outputs, to the use of LLMs to give feedback to LLMs. In this case, to maximise interpretability, I used a benchmark dataset consisting of a curated set of human-coded statements. These statements were annotated by experts and included in previously published results to serve as the gold standard. Thus, it is assumed that the exact annotations are valid, and the only valid way to benchmark the statements which are included. The limited yet high-quality benchmark set provided a controlled environment to measure the accuracy, consistency, and reliability of the LLMs. By leveraging this benchmark, I was able to systematically assess the LLMs’ capability to interpret and annotate policy documents with human-like precision, thus validating their utility in automated IG coding tasks.

To compare the results of the LLM with human annotation, a measure of ‘correctness’ is needed. The simplest measure would be to look for exact matches, and to discard all other possibilities. However, I found this to be overly simplistic, and unlikely to represent a fair comparison, considering that human annotators also exhibit some variation. Instead, two alternative metrics were chosen – Normalised Edit Distance, and Rouge Score.

Edit Distance

Edit distance, measures the minimum number of single-character edits (insertions, deletions, or substitutions) required to transform one string into another. It refers to family of algorithms used to measure these metrics. In this study Levenshtein distance is used (Yujian & Bo, 2007) to measure edit distance. Study conducts a pairwise comparison between the human generated

annotation, and the LLM generated annotation, and measure the edit distance between the two strings. Since longer strings are likely to have higher edit distances, the score must be normalised to the length of the longer string. Thus, the higher possible score is (1) indicating two completely different strings, while two identical strings will have a length of (0). When reporting, the complement of the score ($1 - X$) to align to a worst–best scale of (0-1) is reported.

ROUGE-N Score

ROUGE-N is a set of metrics used to evaluate the quality of text summaries by comparing them to reference summaries. ROUGE stands for Recall-Oriented Understudy for Gisting Evaluation (Lin, 2004). Specifically, ROUGE-N refers to the overlap of n-grams between the generated text and the reference text. N-grams are contiguous sequences of n items from a given text sequence.

ROUGE-1 measures the overlap of unigrams (single words) between the LLM output and the human-coded statement.

ROUGE-2 measures the overlap of bigrams (two consecutive words).

ROUGE-L measures the longest common subsequence, capturing the longest matching sequence of words.

Higher ROUGE-N scores indicate greater similarity between the LLM output and the human-coded statements, reflecting the LLM's ability to generate text that closely aligns with human annotations. In practice, before calculating ROUGE score, the strings are tokenized, and stop words are eliminated.

ROUGE scores are a form of F1 accuracy, which account for both the terms recall of tokens from the reference set, and penalises the inclusion of additional terms. In some cases, I am interested in only Recall, which only counts what percentage of the reference tokens are included in the result. It ignores superfluous content. This may be useful to diagnose issues and identify paths to improving performance.

The detailed results of the validation process, including comprehensive statistical analyses and error analysis, will be covered in Chapter 5.7. This chapter will delve deeper into the performance metrics, providing a granular view of the LLMs' strengths and areas for improvement. Further analysis will explore the implications of these results for future research and practical applications in policy analysis.

Specifically, Chapter 5.8 will discuss the scalability of the LLM-based IG coding approach, potential enhancements to the models, and strategies for integrating LLMs into existing policy analysis frameworks to maximize their utility and impact. Additionally, the chapter will include a detailed examination of error cases, providing insights into common challenges faced by the LLMs and suggesting avenues for future improvements.

Overall, the preliminary results indicate that LLMs are highly capable of performing IG coding tasks with a high degree of accuracy and consistency. The detailed analysis in Chapter 5 will provide a deeper understanding of these capabilities, paving the way for more advanced and scalable applications of LLMs in policy document analysis and beyond.

5.4 Applying Large Language Models

In section 4.4, I identified in-context learning as an effective strategy for applying LLMs to novel tasks with limited data. Here I focus on motivating and collecting the required components for developing, implementing, and testing the LLM. Since previous work on automated annotation of text with LLMs is limited, the guidance on what models is well suited to the task is also limited.

Selection of Models

Pretrained LLM performance is benchmarked against a range of metrics such as ‘Human-Eval’ or ‘MATH.’ These are often effective proxies for a range of text generation and annotation tasks. However, it is unclear if this will always generalise, or if this task will be an exception. Thus, it is important to evaluate a range of seemingly ‘well-performing’ LLMs to assess their performance on this task. A subset of models from different providers, which have been adapted to multiple use cases were investigated here. The performance on the provided annotation task was compared to published benchmark performance of the models. The models chosen for evaluation are: llama3, gemma, phi3, mistral and mixtral. The models are selected based on the diversity of training data, the ability to run the models locally and with relatively few resources, and in secure environments.

Benchmark Data

A well-structured benchmark is essential for fair and consistent evaluation across different models and strategies. However, in the absence of an established dataset, the substitute is to compare the model’s performance against a set of ‘gold standard’ data annotated by different

authors. This approach aims to identify the characteristics and composition of an eventual benchmark dataset that can be used to fairly evaluate LLM performance.

Since the literature does not feature extensive discussions of preexisting benchmarks suited to this task, the reference data needed to be adapted from the works of various authors. Data from Wróblewska (2023) was used for the experiments presented here.

Prompting Strategies

This sub-question examines the impact of various prompting strategies on the performance of LLMs in annotating IG components. It aims to identify the most effective ways to prompt LLMs to achieve accurate and consistent annotations. Of several potential strategies identified, two preliminary strategies were compared – pure instruction-based prompting, and role-based prompting.

5.5 System Design

The research questions are paired with a broader motivation – to use this automated approach to produce IG syntax coded statements from policy documents in the case study. Thus, the software architecture needs to suit to both benchmarking against reference data, but also to provide pragmatic outputs for real world use.

The software architecture has its own design goals:

1. Provide a consistent schema for saving IG statements and their syntax annotation.
2. Dynamically combining models, prompting techniques, and output processing.

The application of LLMs on various reasoning tasks is a recent development, and thus, strategies for adapting the underlying models to tasks are evolving rapidly. Techniques for applying LLMs to Information Extraction tasks are particularly understudied. The software architecture needs to allow for different models, generation techniques, and data to be incorporated into the workflow, while preserving comparability across these permutations.

Two notable design patterns have been used to accomplish these goals – Layering and Composition. These patterns facilitate the seamless integration of new features, models, and strategies, and support the evolution of the system as the field of large language models (LLMs) progresses. The structure of the code focuses on Object Oriented Design principles, while avoiding overly complex or opinionated implementations.

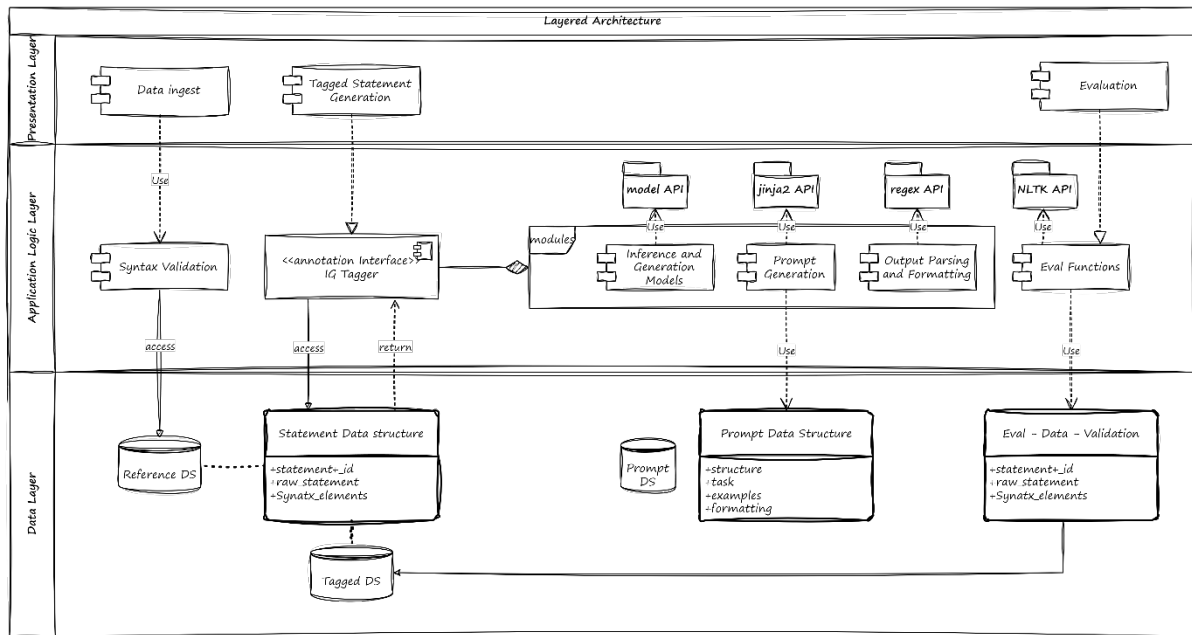


Figure 14 Software Architecture

5.5.1 Layered (Tiered) Architecture

The software follows a layered architecture, where each layer has a distinct responsibility and interacts with adjacent layers. This separation of concerns simplifies maintenance and enhances the modularity of the system (Dey, 2011).

Presentation Layer

Components: User interfaces or API endpoints for interacting with the system.

Responsibility: Handles user inputs and displays results. This layer is responsible for collecting documents, initiating processing, and presenting annotated outputs.

Application Logic Layer

Components: Ingestion Module, Prompt Generation Module, Annotation Generation Module.

Responsibility: Contains the core functionality and business logic of the system. This includes loading and preprocessing documents, generating prompts, and annotating text using LLMs.

Data Layer

Components: Data types for IG statements, Syntax, and Prompts; interface layer for persistent storage of reference and tagged data.

Responsibility: Manages data access and storage. This layer handles the loading of data, validating and ensuring syntax elements are stored in a repeatable configuration, and providing structured access to upstream modules.

5.6 Application Components

5.6.1 Atomic Statement Extraction

In Chapter 4.3, I have established that decomposing documents into atomic institutional statements is an essential part of coding policy statements. The manual decomposition of statements is laborious and requires significant investment from researchers. Here, I highlight a two-stage NLP process that may be used to extract atomic statement. Stage 1 utilizes a rule-based engine to multi-level nested document structures into ‘trees’ of statements, which may then be reorganized to preserve important contextual information. In stage 2, a Large Language Model is introduced, with in-context training to decompose the statements to atomic institutional statements.

This tool forms a critical component of the larger library developed for natural language processing (NLP) and information extraction in this research. By employing regular expressions (regex) to discern hierarchical levels and relationships within texts, this methodology enables a nuanced understanding and extraction of structured information from unstructured or semi-structured text data.

Stage 1: Hierarchical Doc-Tree Parsing

Regular expressions are a powerful tool for pattern matching in strings. In the context of hierarchical text parsing, regex is utilized to identify patterns that indicate different hierarchical levels within a text. These patterns are typically related to formatting elements used in lists, such as bullets, numbers, Roman numerals, and letters, which are common in structured documents like legal texts, academic materials, and technical manuals.

Each type of hierarchical marker (e.g., numbered items, bullets) is described using a regex pattern. Through careful framing of the pattern hierarchy, the parser can recognize and classify lines of text according to their hierarchical significance. The process begins with the definition of a series of regex patterns that correspond to different list types. These may include:

- Numbered items: Patterns that capture sequences like "1.", "1.1.", or "1.1.1.", which typically indicate different levels of hierarchy in numbered lists.

- Bulleted items: Patterns to detect bullet points, which might vary in style across documents but generally represent a single level of hierarchy.
- Roman numerals: Both uppercase and lowercase Roman numerals are used in formal documents, often to denote major sections or sub-sections.
- Alphabetic lists: These include patterns for detecting items marked with letters, often seen in outlines or in the appendices of academic texts.

Each line of text is matched against these patterns. The specificity of the regex allows the parser to not only detect the presence of a hierarchical indicator but also infer the level of hierarchy. For instance, a line starting with "1.1.1." is at a third level of depth relative to "1." or "1.1."

Once hierarchical levels are identified, the text can be organized into a tree structure, where each node represents a block of text at a certain hierarchical level. The root node typically represents the highest level of the document, with child nodes representing nested sub-levels according to the hierarchy determined by the regex matches.

This tree structure is dynamic; as the parser progresses through the text, nodes are added as children to their respective parent nodes based on their inferred hierarchical relationships. This arrangement not only preserves the document's structural integrity but also facilitates complex information extraction tasks by maintaining the context of each text block within the overall hierarchy.

The implementation of this regex-based tree structure parsing methodology is a novel contribution and is applicable to text processing. Outside the use in this workflow, it may be applicable to processing and understanding of laws, contracts, academic papers, instructions, and codes of practice.

Stage 2: Atomic Statement Generation

After the hierarchical doc-tree parsing in Stage 1, the next step is to extract atomic institutional statements from the structured text. This task is accomplished using Large Language Models (LLMs) that can understand the context and generate concise, self-contained statements.

The system employs two different LLMs for generating propositions (atomic statements) from text content. Both models adhere to a common interface that takes the text content, title, and section as input and returns a list of generated propositions.

The first LLM utilizes the T5 model, a powerful text-to-text transformer model, for generating propositions. The input text is formatted by concatenating the title, section, and content (if available). The model then generates output tokens, which are decoded into a string. The generated output is parsed as a JSON list of propositions or split into individual propositions if not in JSON format.

The second LLM uses a custom model specifically designed for proposition generation. The input content is directly passed to the model, which returns the generated output. Similar to the T5 model, the output is parsed as a JSON list or split into individual propositions.

Both LLMs leverage their training on vast amounts of data to understand the context and generate atomic statements from the structured text. They can capture the nuances of language and generate coherent and meaningful propositions.

By integrating these LLMs into the pipeline, the system can effectively extract atomic institutional statements from the hierarchical doc-tree structure. The generated propositions serve as the foundation for further analysis and annotation using the Institutional Grammar framework.

5.7 The Experiment

With these objectives in mind, the following experiment was designed:

Hypothesis: Instruction prompted Large Language Models will identify similar results for IG syntax elements to a human annotator.

The following control variables were identified for this experiment:

1. Datasets

The Wróblewska et al. (2023) dataset was used to evaluate the performance of the system. Wroblewska's coding modifies each statement based on the context of the document. The coding from Wroblewska however, suffers from not being traceable to a specific document or to sentences in a document.

2. Models

Different foundational models, and even different fine-tuning of models can significantly impact model performance. Particularly, 'Instruct Tuning' – modifying purely 'predictive' models to take instructions from text statements and incorporate it into responses – has been shown to

be effective on ‘unseen’ tasks. Different foundational models have shown to be effective at different tasks – and performance on new tasks is not necessarily correlated to performance on other benchmarks.

3. Prompt/Instruction Design

Several authors have shown the effectiveness of instruction in eliciting the desired behaviour from Large Language Models, and the relative efficiency of doing so when training data is sparse. A variety of ‘strategies’ have also been identified, such as ‘Chain of Thought,’ where LLMs are instructed to ‘reason’ about the task prior to giving a response. These methods have also been shown to significantly improve performance in specific contexts.

The experiment explores the impact of different strategies on the system’s performance. Here, the differences are restricted to the content of the prompts and the style of the definitions provided to the LLM.

5.8 Observations

In this section, the results of the evaluation are presented. Before presenting the results, some descriptive information about the datasets is necessary. The number of available syntax elements in each datasets varied. The final counts annotated for each dataset are presented in Table 3.

Table 2 Syntax Counts by dataset

Syntax Elements	Dataset: Wroblewska
Attribute	33
Deontic	30
Aim	33
Direct-Object	28
Indirect-Object	3
Activation-Condition	7
Execution-Constraint	20
Or-Else	0

The absence of coded ‘Or-Else’ conditions is a significant limitation of the datasets.

5.8.1 Per-Syntax, Per Dataset, Per Model Performance

Tables 4 contain the mean-Rouge score for each annotation performed by each model, for the primary prompt case. The scores are in the range of [0,1] where 1 indicates perfect similarity to reference data.

Table 3 Per Syntax Results

Dataset: Wróblewska, Prompt:1					
(Mean Rouge F-Score)	llama3	mistral	mixtral	gemma	phi3
Attribute	0.799	0.874	0.862	0.913	0.46
Deontic	0.967	0.736	0.772	1.0	0.722
Aim	0.57	0.389	0.301	0.588	0.452
Direct-Object	0.288	0.422	0.457	0.555	0.493
Indirect-Object	0.722	1.0	0.0	0.048	0.389
Activation-Condition	0.707	0.746	0.661	0.633	0.764
Execution-Constraint	0.169	0.433	0.232	0.173	0.629
Overall	0.602	0.600	0.543	0.670	0.550

The results suggest strong overall trends – llama3 and gemma are the most consistent performers in most cases, giving better than average results in all cases and topping the performance in some. However, there are intermittent outliers, such as the mistral’s performance in coding Indirect-Objects in the Wroblewska Dataset.

The relatively poor performance in the aim is due to a structural difference between the methods of coding. Most models tend to prefer longer outputs for the aim, and frequently includes the whole verb phrase, rather than just the verb itself. This is shown by the ‘recall’ scores, which are 92% and 95% for llama3 and gemma.

The differences between the performance demonstrate that additional context may be an effective strategy to mitigating the deficiency in the second case.

5.8.2 Comparison to Reference Model Benchmark Performance

Contrary to expectations, model size and model performance in widely accepted benchmarks is not strongly linked to performance under the test case. The comparative performance of the models is presented in Table 4.

Table 4 Comparative Model Performance

Model: Version	MMLU performance	Dataset 1 F-score
llama3:8B	62.55	60.22
mistral:7B	63.4	60.04
mixtral:8X7B	65.81	54.29
gemma:7B	66.03	66.95
phi3:7B	69.9	54.97

5.8.3 LLM Consistency

It is unclear at this stage, why the ‘best’ performing model isn’t consistent across syntax elements or across datasets. This is not attributable to model stochasticity since average model performance remains consistent across runs. Average performance of all models across individual syntax elements is also similar.

Table 5 LLM Consistency

Dataset 1		
Model	Run 1	Run 2
llama3:8B	60.22	63.59
mistral:7B	60.04	62.50
mixtral:8X7B	54.29	51.51
gemma:7B	66.95	67.51
phi3:7B	54.97	55.99

5.8.4 Prompting

Results from the prompt tuning suggest similar performances across the test suite. This is not surprising, since the models adopted a very similar strategy for prompting. Most models experience a modest performance degradation in tagging tasks. The ‘phi3’ model shows a significant improvement however, that persists. This score increase is due to better differentiation between ‘Attributes,’ ‘Direct-Objects’ and ‘Indirect-Objects.’ The impact on the

aggregate score is pronounced because of the frequent occurrence of direct and indirect objects in the dataset.

Table 6 Prompt Performance Comparison

Model	Dataset 1	
	Prompt 1	Prompt 2
llama3:8B	60.22	57.38
mistral:7B	60.04	61.71
mixtral:8X7B	54.29	50.05
gemma:7B	66.95	66.88
phi3:7B	54.97	58.66

5.8.5 Comparison with existing methods

Rice (Rice et al., 2021), Wróblewska (Wróblewska et al., 2023) and Chakraborti (Chakraborti et al., 2024) have all presented and benchmarked NLP based sentence annotation techniques for IG analysis. While Rice has trained a machine learning model that builds on POS tagged sentence data, Chakraborti proposed a rule-based tagging scheme that derives tags from SLR coding applied by the CoreNLP library. Wróblewska's approach is similar, where the sentence dependency tree is processed with a rule based approach to try to determine the appropriate token level attributed. Their reported performance is as below:

Table 7 Comparison with Prior work

Mean F1 Score	Wróblewska	Rice	Chakraborti	LLM - gemma
Attribute	0.51	0.62	0.81	0.913
Object*	0.55	0.76	0.52	0.555*
Deontic	1.00	0.97	0.94	1
Aim	0.99	0.84	0.83	0.588*
Context*	0.53	0.69	NA	0.633*
Overall	0.72	0.74	0.77	0.67

The overall results of llama3 and gemini both exceed the overall F1 score of Attribute and Object tags. Additionally, while Aim and Deontic coding from the deterministic approaches is

still better, these systems do not identify or differentiate between vital details in the context, such as the Activation Condition and Execution Constraints.

This demonstrates the potential for further improvement over existing techniques, even without additional data.

5.9 Conclusions

This chapter has demonstrated the potential of the Institutional Grammar annotator, empowered by Large Language Models (LLMs), to enhance the annotation of climate change adaptation policies. The findings indicate that the developed system not only outperforms previous efforts in terms of accuracy and efficiency but also highlights the viability of LLMs in automating complex policy document annotations. This advancement is crucial for policymakers who require robust tools to ensure that climate adaptation efforts are both effective and equitable.

The research also points to promising future directions. One such area is the exploration of more advanced LLMs, with an order-of-magnitude more parameters, which could offer even greater accuracy and contextual understanding. Furthermore, integrating additional context into the prompt could help cover wider use cases, thereby improving the granularity and relevance of annotations.

This tool already carries the potential to support a policy analysis workflow. In the subsequent design iteration, supporting interfaces will be prototyped that augment a workflow. This chapter sets the stage for subsequent studies to build on these foundations, driving forward the integration of innovative AI technologies in policy analysis.

6 Analysis of Procedural Justice

6.1 Descriptive Coding of Documents

This chapter presents a detailed analysis of procedural justice in the case study of the wastewater project implementation in Chennai, India. As discussed in Section 4.2, the Chennai City Partnership: Sustainable Urban Services Program, funded by the World Bank, aims to improve urban services in the Chennai Metropolitan Area, with a focus on enhancing the quality, sustainability, and resilience of essential services such as wastewater management (World Bank, 2022). The analysis is restricted to the institutional environment governing the implementation of this project, as identified in Chapter 4.

Out of the 10 policy documents applicable to wastewater project implementation in the Chennai context, 5 were chosen for Institutional Analysis. These documents are:

- The Chennai Metropolitan Water Supply and Sewerage Act, 1978
- Tamil Nadu Town Planning Act
- Citizen Charter of CMWSSB
- Tamil Nadu Street Vendors Rules 2015
- Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013

Table 5 provides descriptive information about these documents, including the type of document, authoring body, and word count.

Table 8 Document information

Document	Type	Author	Word Count
The Chennai Metropolitan Water Supply and Sewerage Act, 1978	Act	Government of TN (State)	25,000
TN Town Planning Act	Act	Government of TN (State)	32,000

Citizen Charter of CMWSSB	Policy	Chennai Water Supply and Sewerage Board (Local)	6,000
Tamil Nadu Street Vendors Rules 2015	Rules	Government of TN (State)	12,000
Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013	Act	Government of India (National)	8,500

The selected policy documents were processed using the Automated system, developed in Chapter 5, to extract atomic institutional statements and their corresponding IG syntax elements. This fully automated and unsupervised process identified 5,516 atomic institutional statements from the 5 documents, resulting in 24,695 components and 85,000 total words classified by the tagger. Table 6 presents the counts of atomic statements and IG components identified for each document.

The classification of tokens provides insights into the most important and frequently cited entities across the documents. Annexure 9.3 summarizes the total occurrence of entities in the Attribute and Object syntax positions. The top 25 most frequently occurring entities account for 25% of all entity mentions and 50% of mentions for entities mentioned 4 or more times. Notably, neither street vendors nor sanitation workers, two vulnerable groups identified in the project's social impact assessment, appear in the top 25 mentioned entities.

Clustering by Project Phases

As discussed in Section 4.3, wastewater projects are typically operationalized in 5 phases: design, construction, commissioning, operation, and decommissioning. To further analyse the institutional statements, each statement was manually classified based on the project phase to which it primarily belongs. Due to the manual nature of this task, the classification was restricted to 3 documents: the WSS Act, the Citizen Charter, and the Prevention of Manual Scavenging Act. Annexure 9.5 presents the distribution of institutional statements across project phases for these documents.

The analysis reveals several notable characteristics. None of the statements from the Citizen's Charter are present in the design phase. Out of the 8 statements linked to the 'Design' of wastewater infrastructure in the Prevention of Manual Scavenging and their Rehabilitation Act

(PEMSRA), 6 are related to prohibiting the construction of insanitary latrines, while the remaining two concern the design of a survey to identify potential manual scavengers. This finding suggests a lack of procedurally just practices in the design phase of the project.

Table 9 Statements by Phase

Phase	Chennai Metropolitan WSS Act	CMWSSB Citizens Charter	Prohibition of MS Act	Grand Total
Design	245		8	253
Construction	79		24	103
Commissioning	22		163	185
Operation	856	87	264	1207
Decommissioning	90		14	104
Grand Total	1292	87	473	1852

To further investigate procedural justice aspects specific to the project's design phase, each of the 245 statements concerning this phase was analysed to identify statements matching the structure of a procedurally just statement, as defined in Section 4. The statements were selected based on the presence of procedural justice-related 'Aims' and 'Activation-Conditions', along with the presence of relevant entities in the Attribute and Direct Object positions.

The analysis reveals that while 30 statements are ostensibly related to public procedural values, only one involves citizens as stakeholders in the institutional statement. Statement #954 of the Chennai Wastewater Act mandates that applicants for groundwater extraction licenses must appear for a hearing prior to the grant of licenses, aligning with the value of 'Voice'. All other cases, such as the disclosure of budgets, require submission of budgets from the Board to the Government (Statement #731), without direct citizen involvement.

6.2 Analysing Action Situations

In this section, I further discuss action situations that arise in the 5 phases of Water and Sewage system adaptation to Climate Change. Action situations are identified on the basis of a technical understanding of the WSS life cycle, and the boundaries of the situation are inferred from the temporal and spatial boundaries of actors. Selected action situations are detailed below to illustrate the institutional dependencies and voids that are relevant to procedural justice issues.

6.2.1 Wastewater Project Development

An important part of the maintenance of water and wastewater systems in developing regions is the expansion of services to new areas, upgrades to physical infrastructure to service growing populations, and the modernisation of systems to meet higher standards of service. The rules-in-form allocate the primary responsibility for the selection and framing of projects to the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSA 238,239). These statements also charged the Board with ensuring these projects are ‘for the benefit of inhabitants.’

This institution is modified with the added caveat that WSS schemes may only be adopted by the board with the permission of the State Government (CMWSSA 771). This adds a second condition to the initial statement’s aim – as shown in Figure 15. While the permission of the State is an absolute requirement, it is left up to the Board how to interpret their obligation to the citizens. The Town Planning Act additionally instructs that Chennai Metropolitan Development Authority must ‘consult’ the CMWSSB for the purpose of planning water supply works. A search of the coded institutional statements shows that there are no other statements pertaining to defining or planning water supply and sewerage projects.

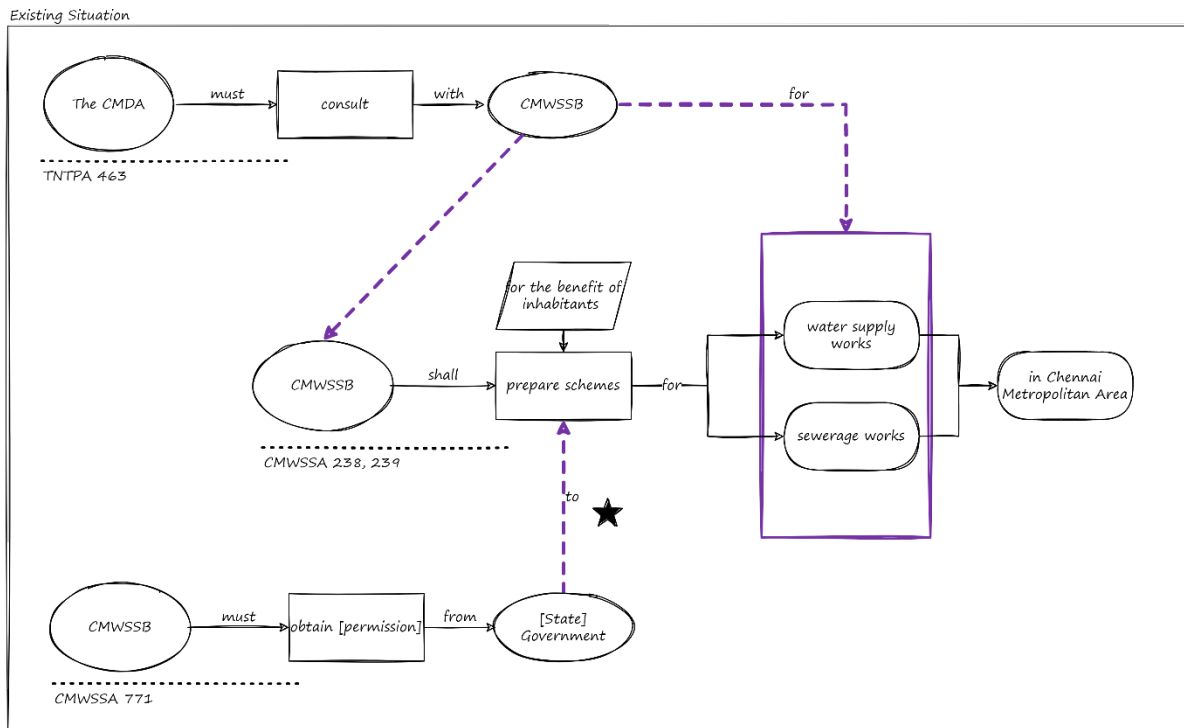


Figure 15 Institutional Environment for Wastewater Project Development

We may now compare this institutional arrangement with the procedural justice principles of Voice, Transparency, Accountability and Correctability. The consultation requirement between CMWSSB and CMDA may be considered a case of Voice, and the requirement of permission from the government may be considered to be a case of Transparency. However, in either case, the requirements may only be considered to be oriented toward the state, and would not ordinarily be considered to directly benefit vulnerable groups. This is reinforced, since the Board is also directly appointed by the government (CMWSSA 165).

The only rule oriented toward ‘citizens’ is the Execution Constraint modifying CMWSSA 238 and 239. However, in the absence of specific processes and conditions that require disclosure (Transparency) or consultation (Voice) through the direct involvement of vulnerable groups, means that the alignment with procedural justice values is weak.

6.2.2 Appeal Process

The ability to appeal decisions and orders given by an authority is a foundational component of procedural justice, epitomised by the principle of Accountability. Figure 17 shows how the institutional mechanisms for appealing rate making decisions are not always aligned with principles of procedural justice.

The CMWSSA provides a general mechanism of appeal through the establishment of the ‘Tribunal’. The Tribunal is empowered to decide matters related to taxes, rates, and payment of dues between owner/occupiers and the CMWSSB. The existence of a clearly defined appellate authority is consistent with the principle of ‘Accountability.’ However, there are two important conflicts in the institutional structure of this provision. First, the appeal to the Tribunal requires that the dues that are being disputed first be paid before the appeal may be heard. Since there is no corresponding requirement for the return of ‘improperly’ claimed dues from the CMWSSB, this requirement directly conflicts with the principle of ‘Correctability.’

Additionally, the appeal to the Tribunal is a terminal process, and the appellant is explicitly precluded from redress in the courts. From the principle of accountability, this also constitutes a direct conflict, since the decision of the Tribunal becomes absolute. The absence of any ongoing monitoring of the Tribunal also constitutes a breach of the principles.

This process is additionally flawed due to the absence of any rules creating transparency and voice for other vulnerable groups such as urban poor groups.

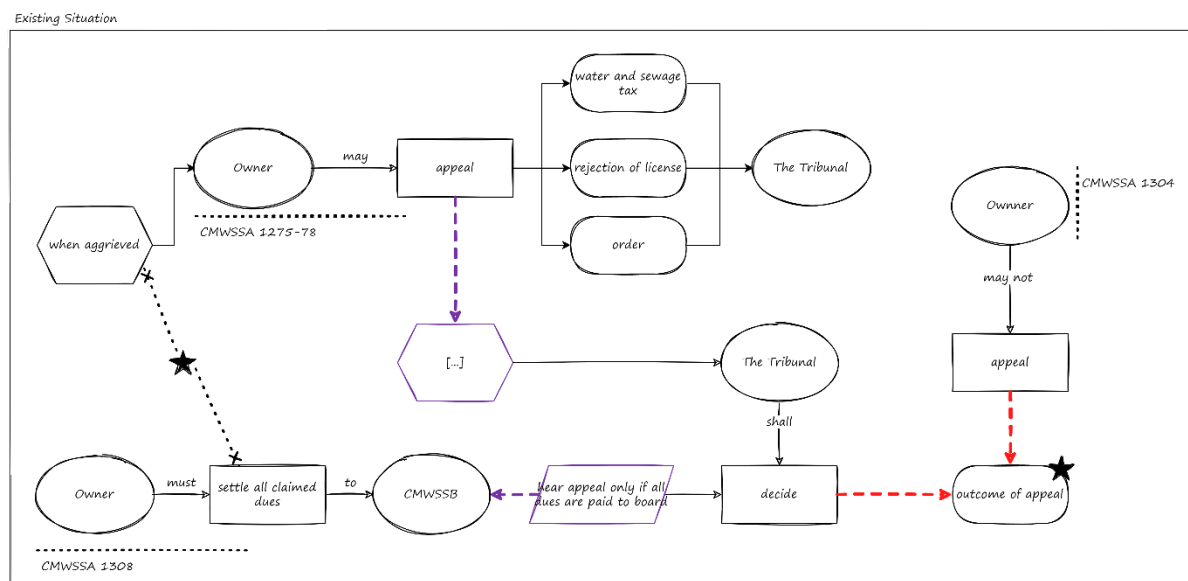


Figure 16 Institutional Environment for Appeal Process

6.2.3 Sanitation Worker’s Lack of access to Grievance Redressal

An area of concern for the wastewater services is providing access to areas where sewer networks have not been introduced. One alternative technology is the use of septic tanks, which temporarily hold and provide primary treatment to wastewater. These tanks need to be periodically emptied. In the context of Chennai, and much of India, the Sanitation Workers that work on emptying septic tanks is vulnerable, and are often stuck in generational cycles of

poverty. In this section, we observe how the institutional environment around the emptying of septic tanks prevents access to CMWSSB Grievance Redressal systems for Sanitation Workers.

The action situation is initiated by the CMWSSB Citizens Charter includes provisions for user requests for septic tank clearance (CMWSSB Citizens Charter 244) and the government's provision of sewer lorries for septic tank cleaning (CMWSSB Citizens Charter 245). The Prohibition of Manual Scavenging Act (MS Act) explicitly prohibits hazardous cleaning of sewers by any person (MS Act 174). This potential conflict is resolved by the internal rules of the CMWSSA.

The Chennai Metropolitan WSS Act mandates the establishment of an Employment Committee (Chennai Metropolitan WSS Act 443) and outlines regulations concerning the duties and terms of service of officers and employees (Chennai Metropolitan WSS Act 1368). These regulations however, defined the scope of the regulations to exclude temporary workers, labour, and entrepreneurs. Since the equipment for tank cleaning is provided for hire, any workers, regardless of social background are entrepreneurs, and hence technically outside the ambit of the MS Act.

The CMWSSB Citizens Charter provides for a Grievance Cell where complaints on various issues, including those from employees, are registered (CMWSSB Citizens Charter 220). However, since this cell is regulated by the Regulations above, this is inaccessible to workers to demand their rights.

Examining the provisions for Procedural Justice values, I see that all four core principles are absent. While Owners are empowered to request services, and Employees may raise grievances, these are not oriented toward the vulnerable residents or workers. Similarly, lack of accountability for the CMWSSB toward sanitation workers, and the explicit exclusion of Sanitation Workers from employment rules presents another risk for procedural justice.

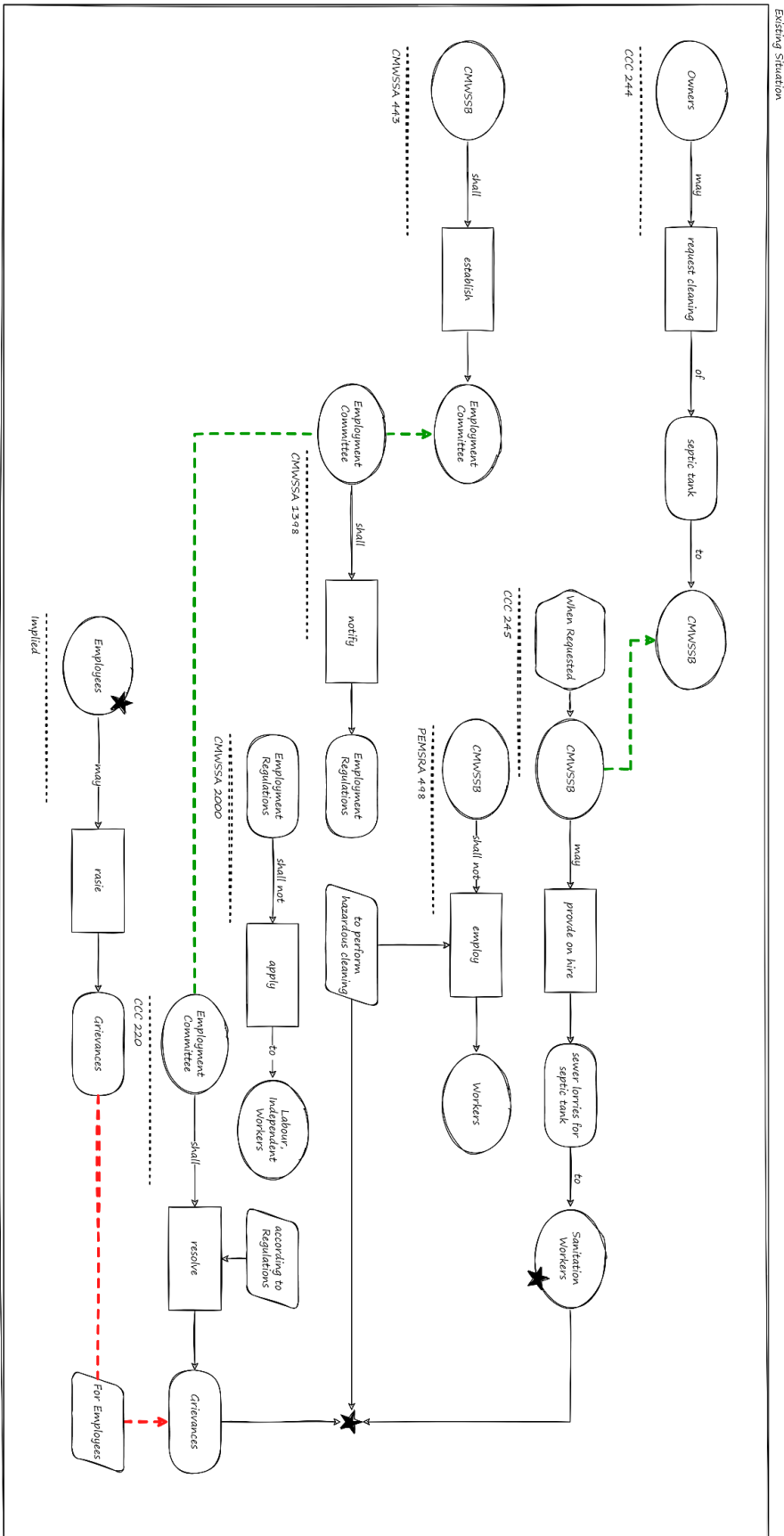


Figure 17 Institutional Environment for Sanitation Worker Employment

6.3 Comparison with World Bank Assessment

The institutional analysis of the Chennai wastewater project case study provides significant evidence that procedural justice considerations are not adequately addressed by the institutional environments governing the Chennai Wastewater Board. The findings highlight the need for greater inclusion of vulnerable groups, such as sanitation workers, in the institutional frameworks governing wastewater projects.

The structure of the existing formal rules indicates that the structural requirements for procedurally just rules are met, but that these requirements are oriented toward the Government and its representatives. Where citizens are addressed by the rules, their interests are defined ambiguously, whereas there are specific requirements in place to protect the interests of the state. References to decision makers within the 'Government' are equally ambiguous, leaving the division of powers within the state ambiguous, limiting Transparency and Accountability.

The World Bank Environmental and Social Assessment Process identifies similar social risks for the project implementation. The assessment highlights overall lack of representation in decision making around where projects are defined. The risks of hazardous cleaning of sewers and septic tanks due to weak institutions around worker's welfare is similarly highlighted. The Bank's assessment also mentions a lack of transparency in the Grievance Redressal process, particularly through field observations around closing complaints in practice.

The Bank's assessment however fails to identify a few cores institutional gaps, such that that highlighted in Chapter 6.2. The need for end-users to clear dues to appeal tariffs conflicts with the Banks' principles but has been missed in their ad-hoc assessment process. Similarly, while the Bank mentions the importance of a strong legal environment for worker's safety, they fail to highlight that sanitation workers are denied recognition are employees of the CMWSSB, limiting their access to workers' rights.

Collectively, the reproduction of insights produced by Bank experts, as well as the generations of new insights around social risks in the institutional environments demonstrates the applicability of the institutional analysis method for procedural justice investigation.

7 Conclusions and Future Work

This research study has provided several key insights into the intersection of procedural justice and climate change adaptation, as well as the potential for Large Language Models (LLMs) to transform the field of Institutional Grammar (IG) research.

7.1 Responding to the Research Questions

7.1.1 Sub Questions 1-3

To answer the primary question, we posed 3 sub-questions. First, we answer these below;

- What are the key principles, or types of practices that indicate alignment or misalignment with procedural justice values in climate change adaptation?

In Chapter 3.1, we explored the philosophical and empirical roots of procedural justice and identified 11 dimensions of procedural justice applicable to climate change adaptation projects. We established that the recognition of stakeholders, and the awareness of their self-identification and experience of vulnerability is a pre-requisite. Thus; **Transparency, Accountability, Neutrality, Correctability, Ethicality, Trustworthiness, Voice, Decision Control, Capability, Respect, and Politeness thus emerge as the key principles that demonstrate alignment with procedural justice values.**

- What insights about procedurally just behaviour can be derived through the institutional analysis of climate change adaptation projects?

In Chapter 3.3, we applied the Institutional Analysis Framework to the abstract values of justice, and mapped their assessment to components of the Action Arena. Through this, we determined that 7 of the 11 values of justice are only visible in the outcomes, interactions, or material realities of the action arena, and are independent of the ‘Institutions (Rules)’. Through this, we determine that Institutional Analysis may help us find evidence for the existence of Accountability, Transparency, Voice, and Correctability in the institutional environment. We use secondary literature that collects empirical evidence for these justice values to define them using Institutional Grammar Syntax. We conclude that **we can derive an understanding of the existence of Accountability, Transparency, Voice, and Correctability in a policy situation, from the perspective of different stakeholder groups, through the institutional analysis of projects.**

- What data sources and methods are needed to empirically assess procedural justice in a policy arena?

Since Procedural Justice is framed as a local issue, the methods for assessing it rely on empirical methods. The case study method is shown to be the appropriate tool for the analysis. We determine our primary data source is the content of the formal rules applicable to an Action Area. The method of analysis was defined as Institutional Network Analysis through the application of the Institutional Grammar as an intermediate step. In Chapter 4 we detail the procedure developed for applying this method.

7.1.2 Primary Question

The primary question to be answered by this research study is:

In what ways do formal rules influence procedural justice in climate change adaptation projects?

Regarding the primary research question of how policy environments influence procedural justice in climate change adaptation projects, this study has demonstrated that formal rules play a significant role in shaping the potential for Voice, Transparency, Accountability, and Correctability - four key dimensions of procedural justice relevant to policy.

Case Study Insights

By systematically analysing the institutional statements and rules governing the case study of wastewater infrastructure adaptation in Chennai, it became evident that the existing policy framework provides limited avenues for meaningful stakeholder engagement, information sharing, oversight mechanisms, and scope for modifications. This indicates that the formal rule environment may not be well-designed to facilitate procedurally just adaptation.

We showed that strong institutional structures are frequently introduced to require Voice, Transparency, Accountability and Correctability – oriented toward the Government and its representatives. However, requirements for these values for vulnerable groups who are directly impacted by such rules are either vague, or absent. The analysis was also able to identify caveats and limitations effectively contradict these values.

This finding adds to the empirical evidence on procedural gaps in adaptation planning and underscores the need for intentional design of rules to address power imbalances.

Broader Insights for Procedural Justice in CCA

The application of the institutional analysis method to the study of procedural justice has surfaced the importance of ‘institutionalisation’ of values. While the strategic use of ambiguity in institutional form has been shown to potentially benefit adaptation; the insights here show that ambiguous and fragmented statements surrounded by less ambiguous ones are at risk of being ignored. The validation of four key attributes of procedural justice through their use in institutional form lays out a path for comparative evaluation of policies and policy environments.

7.1.3 Transformational Potential of Large Language Models in IG Research

The fourth sub-question for this project is:

- How can recent advances in Large Language Models (LLMs) support the automated analysis of policy documents for procedural justice?

In Chapter 5, we demonstrate the LLMs can be used to automate the identification of institutional statements in policy documents and the annotation of those statements with institutional grammar syntax labels. Through the use of open-source and pretrained models, we were able to expand the scope and reduce the timeline for policy document analysis.

Policy statement annotation has been a low resource use-case and the performance of pre-trained models is promising. Using relatively small models with few parameters, the results are approaching human codes for several syntax components. This finding demonstrates the feasibility of reliably leveraging state-of-the-art Natural Language Processing (NLP) techniques in IG research, opening up a wide range of possibilities for large-scale, comparative studies across diverse contexts and time periods.

The use of LLMs is also significant as it addresses issues with traceability and consistency in policy research. The acceptable standard of inter-coder reliability is around 0.8, making LLMs more reliable than the widely accepted 2-coder standard for policy analysis.

7.2 Limitations and Future Work

In this chapter, I address the limitations of the method and opportunities for future work. In each sub-section we first identify the limitations of the current work, and then conclude with potential avenues for future work.

7.2.1 Analysis of Procedural Justice

As an exploratory case, this research focused on a single component of a large Climate Change Adaptation program. This focus helped demonstrate the presence of institutional information and alignment with values. The challenges with this approach are:

1. No evidence of actual behaviour of stakeholders

Since direct assessment of project outcomes and stakeholder decisions is not available, it is difficult to assess whether the institutions-in-form translate to institutions-in-use. A complete assessment of procedural justice would require assessments of which rules are invoked in practice and whether other procedural justice values have been met.

2. Limited Policy Documents Accessed

The policy documents for the case were selected pragmatically, using the existing studies as a guide. However, this restricted the scope of the documents to high level Acts and Rules of the State. Significant policy making, however, takes place in the form of orders, letters, instructions and other official documents and acts of the organisations themselves. The incorporation of these documents would add richness to the analysis.

3. Information on Norms and Shared Strategies

Alongside the rich information of policy within the government, additional information on the experience of stakeholders and their coping strategies is also necessary. Since social norms often fill gaps in ambiguous policy, it follows that these would add valuable information.

4. Comparisons with alternative cases

The current empirical study is restricted to a single case study, it follows that insights about the implications for policy design more broadly are unlikely to generalise. Comparing policies in different environments will provide an opportunity to compare and contrast different institutional designs. Different structures designed to achieve similar objectives is necessary to derive best practices.

Recommendations:

Future research should look into comparative analysis of policy environments, particularly comparing OECD Economies with Emerging Markets. Incorporating a broader dataset, with a focus on decision making within important public and private organisations, is needed.

7.2.2 Large Language Models for Policy Analysis

However, while the development of the LLM tool represents a significant step forward, it also highlights several limitations and challenges that need to be addressed in future research.

Perhaps the most critical issue is the lack of comprehensive, human-annotated datasets for validation purposes. The availability of high-quality, gold standard datasets is essential for evaluating the performance of LLMs and ensuring the reliability and robustness of automated coding results. Creating such datasets would provide a solid foundation for benchmarking different models, fine-tuning hyperparameters, and driving further improvements in model performance.

Another key opportunity for advancing the application of LLMs in IG research lies in experimenting with larger, state-of-the-art language models. The current study utilized models with up to 7 billion parameters, which, while impressive, is still relatively modest compared to the most advanced models available today. For instance, OpenAI's GPT-3 model boasts 175 billion parameters, while Google's Switch Transformer has a staggering 1.6 trillion parameters. These larger models have demonstrated remarkable capabilities in various NLP tasks, including language understanding, generation, and reasoning. By harnessing the power of these more expansive models, we may be able to achieve even greater accuracy, nuance, and contextual understanding in automated IG analysis.

Moreover, there is substantial room for exploring more sophisticated prompting strategies to elicit better performance from LLMs. The current study employed relatively basic prompting techniques, leaving ample opportunity for experimentation with advanced approaches such as chain-of-thought prompting, few-shot learning, and task-specific fine-tuning. Chain-of-thought prompting, in particular, has shown promise in improving the reasoning abilities of LLMs by encouraging step-by-step problem-solving. By incorporating this technique, we may be able to enhance the model's capacity to navigate complex institutional arrangements and capture subtle nuances in policy language.

In addition to refining prompting strategies, providing more extensive context to the models could yield significant improvements in performance. The current study supplied limited context to the LLMs, potentially constraining their ability to fully grasp the broader institutional landscape. By feeding the models with a richer set of background information, such as relevant legal frameworks, organizational structures, and stakeholder relationships, we may be able to improve their understanding of the policy environment and generate more accurate and insightful annotations.

Furthermore, testing complex combinations of prompts and instructions could help uncover optimal configurations for specific IG analysis tasks. Diverse types of institutional statements may require tailored prompting approaches to maximize the effectiveness of the LLM tool. By systematically exploring various permutations of prompts, context, and model architectures, we can develop a more nuanced understanding of how-to best leverage LLMs for different aspects of IG research.

As the capabilities of LLMs continue to evolve at a rapid pace, there will be no shortage of opportunities to refine and optimize their application to IG research. The development of more advanced models, such as those incorporating explicit reasoning capabilities or domain-specific knowledge, could open up new frontiers in automated institutional analysis. Similarly, the integration of LLMs with other AI techniques, such as knowledge graphs or reinforcement learning, could enable more sophisticated forms of reasoning and decision-making in the context of institutional arrangements.

7.3 Conclusion

In conclusion, this thesis has not only deepened our understanding of how policy environments engage with procedural justice in climate adaptation but has also pioneered a new frontier in the methodological landscape of institutional analysis. The LLM-powered annotation tool developed here has the potential to be a game-changer, enabling researchers to efficiently process vast amounts of policy data and uncover patterns that were previously difficult to discern. By combining conceptual advancements in procedural justice with cutting-edge computational methods, this study paves the way for a new generation of IG research that can inform the design of more equitable and effective climate adaptation policies. As the urgency of climate action grows, such interdisciplinary efforts to bridge the gap between institutional theory and practice will be increasingly vital.

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9 Annexures

9.1 Codebase

The code and external dependencies used for this project are available at

[MechaKaradi/IG_LLM_Tagging: POC for the use of llms to tag statemtents with the Institutional Grammar \(github.com\)](#)

9.2 Data

The result from the automated annotation of the policy documents is shared here:

[Releases · MechaKaradi/IG_LLM_Tagging \(github.com\)](#)

9.3 Syntax Counts

Documents	ATTRIBUTES	DEONTICS	AIMs	DIRECT_OBJECTS	INDIRECT_OBJECTS	ACTIVATION_CONDITIONS	EXECUTION_CONSTRAINTs	OR_ELSES	IG STATEMENTS
Chennai Metropolitan WSS Act	1451	1588	1643	1615	159	933	72	17	1662
CMWSSB Citizens Charter	201	147	313	325	48	57	182		343
Prohibition of MS Act	504	536	555	540	51	324	30	8	565
TN Street Vending Rules	699	735	756	750	129	459	55	9	776
TN Town Planning Act	1772	2070	2147	2122	233	1320	103	37	2170
Grand Total	4627	5076	5414	5352	620	3093	442	71	5516

9.4 Frequently Occurring Entities

Row Labels	TN Town Planning Act	Chennai Metropolitan WSS Act	TN Street Vending Rules	Prohibition of MS Act	CMWSSB Citizens Charter	Grand Total
board	51	462			43	556
government	322	95	32	24	1	474
town vending committee			141			141
local authority	27	30	58	17		132
authorised authority		125				125
person	33	75	6	8		122
any person	54	31	1	7		93
planning authority	91					91
rules	61	3		16		80
authority	49	22	6	3		80
appropriate planning authority	75					75
returning officer			70			70
regulations	22	43				65

tribunal	40	24			64
metropolitan development authority	64				64
owner	29	31			60
local planning authority	58				58
regional plan	57				57
director	48	3			51
state government	1	2	2	44	49
planning authorities	48				48

9.5 Statements Matching Procedural Values Syntax

Value	AIM	ACTIVATION_CONDITION
Accountability	adopt	if cost exceeds or is likely to exceed previous sanction of government
	adopt or execute	cost is met or to be met with from funds provided by government
		previously sanctioned by government
	be sued	(blank)
	disallow	within one month after receipt
Correctability	obtain previous sanction	adopting or executing any scheme or plan in respect of water works or sewerage works
		carrying out any work in connection with water works or sewerage works
	approve amended budget	(blank)
	be deemed to be validly done or taken	on or after 1st day of march 1977 and before date of publication of this act in Tamil nadu government gazette
	be validly done or taken	on or after 1st day of march 1977 and before date of publication of this act in Tamil nadu government gazette

	cause removal or other dealing	erection of a building wall or other structure
	return budget	(blank)
	review and revise	periodically
Transparency	be notified	15 days before any work under this section is commenced
		establishment of board under section 3
	furnish	existing authority is a party to legal proceedings covered by section 30
		transfer of properties to board under this act
		(blank)
		establishment of board under section 3
	furnish information	immediately after establishment of board under section 3
		notified date
	give written notice	15 days before any work under this section is commenced
	resubmit	(blank)
	submit	(blank)
Voice	be refused a licence	unless they have been given an opportunity to be heard