Shale Gas in South Africa: Energy Discourse and the Making and Governing of Resources

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This thesis is submitted for the degree of Doctor of Philosophy

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February 2024

This PhD was supported by ESRC NWSSDTP CASE studentship in collaboration with the British Geological Survey University Funding Initiative.

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Abstract

This thesis is a study of the issues involved in the development of shale gas resources in South Africa, and of the challenges of implementing policies which have interconnected political, social, ecological, and economic implications. This research explores how shale gas narratives are shaped and used by the various stakeholders involved, and analyses the governance arrangements which would be necessary if shale gas exploitation at scale is to be realised, taking as a specific example that of groundwater governance. This research is intended to be relevant to various stakeholders, and to inform their decision-making processes and policy-implementation.

This thesis consists of three papers, each addressing a specific aspect of the shale debate, together with an introduction, a literature review, an account of methodology, and a conclusion.

Paper 1 is an exploration of the contested role of shale gas in South Africa's "Just Energy Transition", based on an analysis of the perspectives of the Commissioners of the Presidential Climate Commission. Using document analysis and interviews, the research identifies areas of consensus and dispute regarding the role of shale gas among key stakeholders, and draws out the particular interpretations of justice that they mobilise. The analysis reveals that the principles of restorative, distributive, and procedural justice feature prominently in the national energy transition narrative, but that there remain significant differences in approach to gas policy, and the interpretations of the principles of justice in the just energy transition.

Paper 2 focuses on the use of resource estimates from the perspective of critical resource geography, and examines the deployment of resource-making practices and geo-imaginaries in the shaping of the national shale gas discourse; this paper draws on government documents, the media, and interviews to evaluate this specific aspect of evolving shale narratives. Key findings include the continued use of high-end shale gas resource estimates in government geo-imaginaries, that are identified as a significant factor in resource-making narratives. Further, it is argued that existing and imperfect data is being repackaged as new

research, to maintain the preferred geo-imaginary narratives of the gatekeepers of geo-scientific knowledge, and to justify the continued mobilisation of state resources.

Paper 3 analyses the multiple dimensions of groundwater governance relating to the development of unconventional oil and gas in South Africa, their complexity and adequacy. Based on interviews and stakeholder engagement, the research explores the roles of stakeholders, of policies, and of legislation, in the particular context of South Africa. Key findings include: 1) the need for continued stakeholder engagement, and follow-through on the outcomes of these processes; 2) the necessity for detailed groundwater-specific regulations to be drafted at the earliest opportunity; 3) the prevalence of significant governance gaps, particularly regarding regulatory and institutional capacity.

This thesis contributes to wider debates about shale gas by providing an analytical appraisal of the politics of resource-making, governance and decision-making in the under-examined context of South Africa within its particular geographic and political setting. Through a mixed methodological approach, areas of contemporary policy debate are identified, and by expanding on the critical geographies literature, a unique insight into South Africa’s shale dialogue is provided. By expanding these theoretical approaches and examining direct governance implications, the thesis offers a detailed evaluation of shale gas policy and groundwater governance in South Africa.

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List of Abbreviations

ANC - African National Congress

Bcm - Billion cubic metres

BGS - British Geological Survey

CAT - Climate Action Tracker

CEF – Central Energy Fund

CER - Centre for Environmental Rights

CFC - Chlorofluorocarbon

CGS – Council for Geoscience

COP - Conference of the Parties

COSATU - Congress of South African Trade Unions

CPR - Common-pool resource

CSIR - Council for Scientific and Industrial Research

CTI - Carbon Tracker Initiative

DFFE - Department of Forestry, Fisheries and the Environment

DMR - Department of Mineral Resources

DMRE - Department of Mineral Resources and Energy

DWA – Department of Water Affairs

DWS – Department of Water and Sanitation

ECMk - Energy Accreditation Scheme

ECs - European Commissions

EGD - European Green Deal

EGSA - Energy Governance South Africa

EIAs - Environmental impact assessment

EPOR - Empirical Program of Relativity

ERSS - Energy Resource & Social Science

FAO – Food and Agriculture Organization

FEDUSA - Federation of Unions of South Africa

GEF – Global Environment Facility

GEF-GD - Global Environmental Facility - Global Diagnostics

GHG - greenhouse gas

GND - United States Green New Deal

GUMP – Gas Utility Master Plan

GW - Gigawatt

GWG - Groundwater governance

HVHF - High volume hydraulic fracturing

IAH - International Association of Hydrogeologists

IAR – Integrated Annual Report

IEA - International Energy Agency

IEP - Integrated Energy Plan

IGRAC - International Groundwater Resources Assessment Centre

IGS- Institute for Groundwater Studies

IISD - International Institute for Sustainable Development

IPBES - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IPCC - Intergovernmental Panel on Climate Change

IRP - Integrated Resource Plan

ISD – Invisible, slow, and distributed

IWRM - Integrated Water Resource Management

JETP – Just Energy Transition Partnership

KDDP - Karoo Deep Drilling project

LNG - liquified natural gas

LU - Lancaster University

MEC - Mineral Energy Complex

MPRA - National Environmental Management: Protected Areas Act

NBI - National Bureau of Investigation

NBI - National Business initiative

NDCs - nationally determined contributions

NEMA – National Environmental Management Act

NGO - non-governmental organisation

NUM - National Union of Mineworkers

NUMSA - National Union of Metalworkers in South Africa

NWA – National Water Act

OCGTs - open cycle gas turbines

PASA – Petroleum Agency South Africa

PCC - Presidential Climate Commission

REIPPP - Renewable Energy Independent Power Procurement Program

RSA - Republic of South Africa

SACP - South African Communist Party

SADC GMI – Southern African Development Community Groundwater Management Institute

SAHRA - South African Heritage Resources Agency

SANEA - South African National Energy Association

SAOGA - South African Oil & Gas Alliance

SEA - Strategic environmental assessment

SGDCK - Shale Gas Development in the Central Karoo

SKAD – Sociology of Knowledge Approach to Discourse

SOEKOR - The Southern Oil Exploration Corporation

SONA - State of the National Address

STS - Science and Technology Studies

Tcf - Trillion cubic feet

TCPs – Technical Cooperation Permits

TKAG - Treasure the Karoo Action Group

TWh - Terawatt hour

UFS - University of the Free State

UNFCCC - United Nations Framework Convention on Climate Change

UOG – Unconventional oil and Gas

USEIA - United States Energy Information Administration

USGS - United States Geological Survey

WRC - Water Research Commission

WUA – Water use associations

WWF - World Wide Fund for Nature

ZAECMKHC - Eastern Cape High Court

ZASCA - Supreme Court of appeal for South Africa

Acknowledgments

I would like to express my sincere gratitude to my supervisory team - to Dr Alexandra Gormally-Sutton for facilitating this unusual project, and to Professor Gordon Walker for joining the project when the need arose, and for seeing it through irrespective of the usual significance of retirement. Your combined input has been invaluable.

I would also like to thank Jamaine, Madelaine, and Foeta. First, for your generous (and seemingly unlimited) hospitality, and second, for providing a window into a complex social and political world. Your relentless commitment to the free press, despite the personal cost, is inspiring.

Thank you to D Ward and Sons. Master engineers, and considerate employers.

To Lorraine and Stephen, for your unwavering support. And everything else.

To my wife, Leila, words are inadequate.

Finally, an impersonal thanks must go to “the blind Fury with th’abhorred shears” for keeping away. Again.

Author’s Declaration

This thesis is my own work and has not been submitted for the award of a higher degree elsewhere. This thesis contains three papers that have either been published, submitted, or are in preparation for submission. They are listed below with a brief description of the contribution that my co-authors and I made. The word count of this thesis is ≈ 60,000 words, and it does not exceed the permitted maximum.

1. **Hemingway, J.R.,** Gormally-Sutton, A., and Walker., G. How the role of gas is framed in South African energy discourse, and the Just Energy Transition. **CRediT authorship contribution statement – Jack Roderick Hemingway:** Conceptualisation, Data curation, Formal Analysis, Investigation, Project administration, Resources, Validation, Visualisation, Writing – original draft, Writing – review & editing. **Alexandra Gomally-Sutton**: Writing – review & editing, Funding acquisition. **Gordon Walker**: Writing – review & editing.

2. **Hemingway, J.R.,** Gormally-Sutton, A., and Walker., G. How the role of gas is framed in South African energy discourse, and the Just Energy Transition. **CRediT authorship contribution statement – Jack Roderick Hemingway:** Conceptualisation, Data curation, Formal Analysis, Investigation, Project administration, Resources, Validation, Visualisation, Writing – original draft, Writing – review & editing. **Alexandra Gomally-Sutton**: Writing – review & editing, Funding acquisition. **Gordon Walker**: Writing – review & editing.

3. **Hemingway, J.R.,** and Gormally-Sutton, A. (2023) An analysis of perspectives on groundwater governance arrangements relating to the potential development of unconventional oil and gas in South Africa. *Hydrogeology Journal,* https://doi.org/10.1007/s10040-023-02742-2. **CRediT authorship contribution statement – Jack Roderick Hemingway:** Conceptualisation, Data curation, Formal Analysis, Investigation, Project administration, Resources, Validation, Visualisation, Writing – original draft, Writing – review & editing. **Alexandra Gomally-Sutton**: Writing – review & editing, Funding acquisition.

1. Introduction and thesis

South Africa is seeing an increased interest in the exploitation of its potentially extensive indigenous gas reserves, which, if realised, could fundamentally alter the country's energy landscape. Gas production has been promoted as a means of boosting the national economy, and of providing a much-needed revenue stream to fund the social objectives outlined in the National Development Plan 2030. These include eliminating poverty, reducing inequality, creating jobs, and facilitating skills development. Gas has also been seen as a means of meeting the national climate commitments, by facilitating energy transition from its current coal-dominated basis to a future renewable energy system. And indigenous gas has also been promoted as a way to increase national energy security by reducing the need for petroleum imports, and as part of the solution to its ongoing energy crisis, in which rolling blackouts, or "loadshedding," are regular occurrences. But, as in other countries, the continued use of gas, or the development of new gas resources, both as a means of energy production in itself, and as a component of the energy transition, is proving controversial. This is particularly so when gas resources are "unconventional," derived from high-volume hydraulic fracturing (HVHF) processes.

Embedded in these promises of socio-economic growth, energy security, and the green credentials of gas, are a number of scientific and economic uncertainties, notably the actual volumes of national gas resources, as well as the environmental impacts of their extraction and use. Such uncertainties must affect the potential socio-economic and socio-ecological benefit of indigenous gas resource development, so they are now a feature in the South African energy policy landscape. How to resolve these dilemmas, and how to balance the associated risks and benefits, has polarised the energy policy and energy transition debate in South Africa.

The South African energy landscape has a number of distinct, though interconnected, stakeholder groups, with varying degrees of influence over energy policy. The political sphere is dominated by the African National Congress (ANC), who have held power in South Africa since its transition to a democratic republic in 1994 following the ending of the abhorrent apartheid regime. The organised labour movements in the country, which were a fundamental component in the democratic transition, remain politically connected, and are at once a powerful influence in shaping government policy, and also deeply embedded in the current energy-production system. There is also a well-established, progressive environmental movement, broadly opposed to fossil fuels, and various sectoral stakeholder groups, all going to create a diverse and complicated socio-political scenario in which energy policy must be worked out.

Underpinning the positions of all these different stakeholder groups, is the recurring theme of justice, with its contested interpretations. These include historic injustices, and current principles of distributive and restorative justice, all interwoven with energy policy decision-making processes. The different emphases of these principles engender an intricate web of stakeholder coalitions and dynamics.

Geoscientific knowledge, and how such knowledge is made and represented by different stakeholder groups, influence policy-making decisions and the dynamics between these groups. Resource-making practices, that is, the varying social and scientific investigation of undeveloped natural resources that renders them knowable, and thereby *valuable*, in various contextual senses, are fed into the national energy landscape by being represented by various actors through a series of geo- and sociotechnical imaginaries horizons. These horizons, which transform the uncertainty of speculative geoscientific knowledge into endless possibility, encapsulate the various socio-technical and socio-economic policy preferences of different stakeholder groups, and particularly those of the most influential in the decision-making processes.

With the prospect of large-scale shale gas resource development as the root of many of these geo- and sociotechnical imaginaries, how their realisation might manifest in practice has become a source of concern among many stakeholder groups. Among these concerns is the suitability of existing legislative, institutional, and regulatory frameworks to effectively govern a radical departure from the existing energy system, with potentially deleterious social and ecological impacts a consequence of their failure to do so.

This thesis and the three papers which are at its core, will, therefore, address these different components of gas resource development in South Africa, and the rest of this introductory chapter will provide a context for the work, outline the aims of the research, and how it contributes to the existing literature.

1.1. Background: shale gas in the Karoo

The presence of oil and gas reserves in the Karoo Basin has been known since the 1960s, when the newly established Soekor (Suidelike Olie Eksplorasie Korporasie - Southern Oil Exploration Corporation) began inland exploration, and found promising oil and gas reserves in Soekor borehole CK1/68 (Esterhuyse, 2023; PASA – History, n.d.). Following the shale gas revolution in the United States (US), triggered by the technological advancements in HVHF techniques at the turn of the millennium, there was a renewed interest in the prospective oil and gas reserves in the Karoo Basin (Pieterson et al., 2021). In 2009 /2010, the Petroleum

Agency of South Africa (PASA) authorised Technical Cooperation Permits (TCPs) to the Falcon Oil and Gas, Shell B.V. International and Sasol-Chesapeake-Statoil consortium to conduct a shale gas assessment in the Karoo (Esterhuyse, 2023; PASA – Onshore, n.d.). In 2010, Shell submitted an exploration licence application (Esterhuyse, 2023). In 2011, United States Energy Information Administration (EIA hereafter) estimated[1] that the Karoo Basin held a technically recoverable shale gas reserve of 485 trillion cubic feet (Tcf), which, according to these estimates, was the world's fourth largest national shale gas resource. (EIA, 2013). These events triggered a number of reactions, including the formation of various activist groups opposed to shale gas resource development, and legal challenges to prevent shale gas resource development. These actions resulted in a moratorium on oil and gas exploration being imposed in April 2011 (Esterhuyse, 2023). Since then, the situation could broadly be described as being in a state of flux. [2] There have been numerous legislative rulings, moratoria lifted and reinstated, and a series of revaluations of the shale resource estimated in the Karoo.

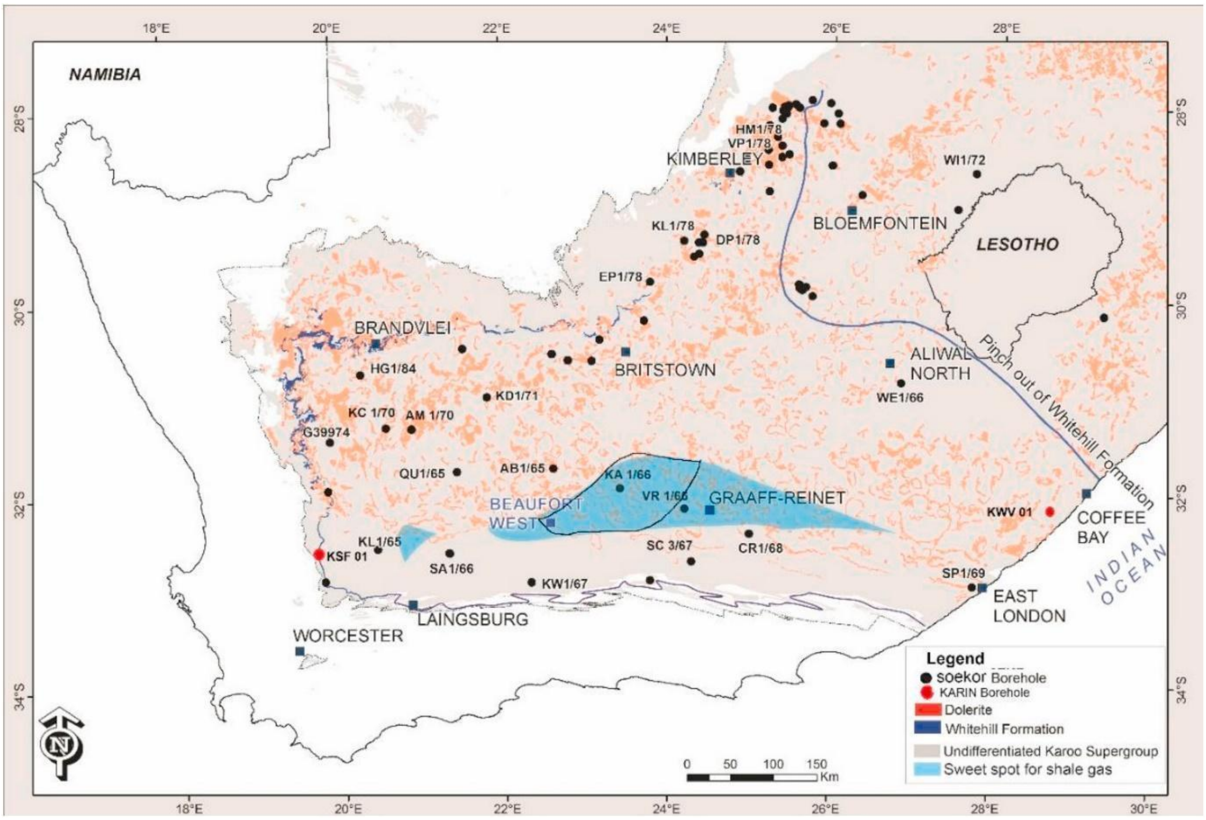

Figure 1.1: Karoo map sweet spot

There have however, also been constants. The ANC has remained resolute in its desire to pursue shale gas resource development in the Karoo, although the details of its policy on the

[1] See section 3.3.2 for a detailed outline of the EIA's methodological approach.

[2] See appendix i for a comprehensive historical timeline of events relating to shale gas resource development in the Karoo.

matter are vague. The 2019 Integrated Resource Plan (IRP)[3] is the latest formal energy policy document, and states:

> "Indigenous gas like coal-bed methane and ultimately shale gas, could form a central part of our strategy for regional economic integration within SADC" (DMRE – IRP, 2019).

But informal policy, as demonstrated in the document analyses of this research, show a clear and consistent pro-shale development stance. The other constant, despite various other resource estimates emerging, is the ANC's persistence in adopting high-end resource estimates (demonstrated in Paper 2). And a final notable constant is that shale gas resource development has been widely opposed, by a broad range of stakeholders throughout this process, as documented in Papers 1 and 2.

During this time, there has been a lot of work on shale gas resource development in the Karoo. This includes the 2016 strategic environmental assessment of shale gas in the Karoo (SGDCK hereafter), commissioned by the (then) Department of Environmental Affairs, led by Professor Bob Scholes, and coordinated and published by the Council for Scientific and Industrial Research (CSIR):

> "The mission statement for the [strategic environmental assessment] SEA is to provide an integrated assessment and decision-making framework to enable South Africa to establish effective policy, legislation and sustainability conditions under which [shale gas development] SGD could occur" (SGDCK, 2016 p. 4).

This multi-author document, inspired by the format of Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), uses a three-scenario approach in its assessment. These are: scenario 1: exploration only (no gas found); scenario 2: small gas (economically viable discovery of ≈5 Tcf); 3: big gas (economically viable discovery of ≈20 Tcf).

There have also been developments on the regulatory and legislative fronts, although much slower than many stakeholders had hoped for. These included the final 'fracking regulations' promulgated by the Minister of Mineral Resources under Regulation R.466 in Government Gazette No 3855 dated 3 June 2015; the draft upstream petroleum resources development bill (UPRDB), published in (December, 2019; The Department of Water Affairs (DWA) draft regulations to protect water resources during UOG extraction for public comment (Sisulu, 2020); The Department of Forestry, Fisheries and the Environment (DFFE) publishes draft

[3] The Integrated Resource Plan (IRP) is a living plan that is expected to be continuously revised and updated as necessitated by changing circumstances. It was first promulgated in March 2011, and the last review of the IRP was done in 2019 (DMRE – IRP, 2024).

regulations to protect the environment as well as minimum requirements for the submission of licences during UO extraction for public comment (July, 2022) (Esterhuyse, 2023). The regular use of the prefix “draft” is noteworthy, and the reasons for, and the ramifications of, this non-commitment to formal policy and legislation are discussed throughout this research.

There have also been further scientific developments, notably, the Karoo Deep Drilling Project (KDDP hereafter), conducted by the Council for Geoscience (CGS) on behalf of the Department of Mineral Resources (DMRE). The KDDP is a geo-environmental baseline project, exploring the minerals, gas, deep groundwater, and geothermal properties of the Karoo basin, with a particular focus on the possible future development of shale gas resources (CGS – KDDP, n.d.). The project began in 2018, and is ongoing, and involves the drilling and coring of an array of deep and shallow boreholes (see Paper 2). An additional groundwater baseline programme has been set up, appointed by PASA, and designed and conducted with hydrogeological experts from the Institute for Groundwater Studies (IGS) at the University of the Free State (UFS) (see Paper 3). Finally, de Kock et al. (2017) (see Paper 2) published the first study of direct measurements of the actual gas contents of southern Karoo basin shales, which concluded:

> “Very likely the most realistic resource estimates for the Karoo basin are between 13–49 Tcf, with the lower estimate perhaps being the most realistic given the sparsity of data” (de Kock et al., 2017 p. 11).

Although much lower than previous estimates, this is still a significant resource, which broadly aligns with the SGRDK (2016) “big gas” scenario.

Finally, in 2018 PASA released their updated shale gas resource estimates of ≈205 Tcf, though it has proved difficult to determine the methodological approach used to reach this estimate: this is discussed in Paper 2, and elsewhere in the thesis.

1.1.1. Background: other developments

Although not explicitly addressed in this research, offshore gas resources are relevant to it, especially when discussing the overall role of gas in energy transition (Paper 1), the broader geo- and sociotechnical imaginaries (Paper 2), and the legislative and regulatory frameworks (Paper 3). It is estimated South Africa has 60 Tcf offshore gas reserves (PASA n.d.), and these resources have had a similarly turbulent legislative and regulatory experience as shale gas resource development (see Paper 3 section 6.5.2). Their development is looking increasingly likely following recent legislative rulings (MMRE, 2021).

And, finally, there has been established an independent, 'multi-stakeholder' agency to oversee the national energy transition, the Presidential Climate Commission (PCC). This has been designed to encourage stakeholder engagement, via its inclusive and diverse Commission, and given the authority of being chaired by President Ramaphosa (Connolly, 2022). The PCC has produced several detailed reports, and has hosted a number of stakeholder engagement events, in line with its commitment to transparency and public participation (Connolly, 2022). The PCC is discussed at length throughout this research, and forms part of the methodological framework in Paper 1.

1.2. Thesis aims and research questions

This thesis is a study of the issues involved in the development of shale gas resources in South Africa, and of the challenges of implementing policies which have interconnected political, social, ecological, and economic implications. This research explores how shale gas narratives are shaped and used by the various stakeholders involved, and analyses the governance arrangements which would be necessary if shale gas exploitation at scale is to be realised, taking as a specific example that of groundwater governance. This research is intended to be relevant to various stakeholders, and to inform their decision-making processes and policy-implementation.

This thesis contributes to the shale gas debate by providing an analytical appraisal of decision-making processes, and a detailed examination of putting policy into practice. The research provides a real time appraisal of a significant energy policy event in South Africa. Through a mixed methodological approach, areas of contemporary policy debate are identified, and by expanding on critical geographies literature, a unique insight into South Africa's shale dialogue emerges. By expanding these theoretical approaches and examining direct governance implications, the thesis contributes a unique and detailed evaluation of shale gas policy and common-pool resource governance in South Africa.

It is to be hoped that this thesis will shed light on a complex issue, that it will have some value both to the academy and to the evolving theoretical discussions addressed in it, but also to the broad range of stakeholders with an interest in this ongoing debate. And, whatever its immediate value, this thesis can be expected to be useful as an archival document which recorded processes and issues of a specific time, in a pivotal period in the evolving energy situation in South Africa.

As was outlined at the beginning of this chapter this research is wide in scope, but its structure is informed by the key themes identified in the common-pool resources (CPR) literature. These are: 1) actors; 2) regulatory, legal and institutional frameworks; 3) policies; and, 4) knowledge, information and science. These themes occur throughout the thesis, and were used as the basis for much of the preliminary research. They are also employed broadly as a means to structure the thesis when other theoretical concepts, such as those of science and technology studies (STS), critical resource geographies, and ideas embedded in the Just Energy Transition literature, are introduced to complement the CPR framing (see chapter 2). This approach was adopted, because although the key themes provide useful structure and insight into the research questions addressed in this thesis (see below), they were not always sufficient to adequately interrogate the questions, and accordingly, further concepts were introduced. For example, in paper 1, the CPR themes provide the theoretical background, so that actors, policies, and institutions were mapped (section 3.2), but this approach needed complementary ideas stemming from the STS literature, *e.g.* the core set. As a result the Presidential Climate Commission and its Commissioners were decided upon as the primary data source for the research (see section 4.4). Similarly, in paper 2, the themes of actors (particularly gatekeepers), and knowledge, information and science provided the backbone of the research, but it was necessary to introduce concepts from critical resource geographies to get a richer understanding of how geoscientific knowledge is created and shared in order to more effectively tackle research question 2. By having these key themes to provide structure, and introducing other academic concepts when required, a more broad conceptual umbrella was established to tackle this diverse subject. And it is using this approach that I seek to address the following questions:

Research Question 1: How do different actors envisage the role of gas in South Africa's future energy mix, and how are these positions framed? What dynamics and tensions emerge between stakeholder groups?

Research Question 2: How does geoscientific knowledge feature in government narratives? Are these framings integrated within wider socio-political and socio-economic debates?

Research Question 3: What changes to existing groundwater governance arrangements are needed in South Africa to mitigate the potentially deleterious consequences to groundwater resources of shale gas development?

1.3. Thesis outline and paper findings and contributions

The structure of this thesis is based on three research papers which contain the findings of the research and describe the methodology used in the process. Each paper addresses one of the three research questions, though the aim of each paper is distinct, and they are not sequential. What follows is a summary of the papers in turn, with the intention of showing how various concepts were approached in each one.

Paper 1[4] draws on the ideas of the CPR and STS literatures, and identifies the PCC as the core set of stakeholders involved in the energy transition governance process (Connolly, 2022), if not necessarily in the decision-making process itself (as it is argued throughout this thesis, the latter is largely undertaken by the ANC alone). Focusing on this broad coalition of stakeholders, I seek to establish the differing views of how the role of gas is framed in South African energy discourse, and how concepts of justice feature within them (Rafey and Sovacool, 2011; Sovacool et al., 2017). Discourse analysis was the main methodological basis here, though it was complemented by the outcomes of the interview processes discussed in chapter 3 (not, though, as a primary data source). Primary data came from publications relating to the Commissioners, or the institutions they represent. In the case of the Ministerial component of the Commission, the data was largely, though not exclusively, derived from their speeches. By integrating the critical resource geography literature with the findings of the discourse analysis (stakeholder framing of the role of gas) there emerged narratives of energy security, socio-economics, and environment. The purpose was not only to establish individual narratives, but to demonstrate where consensus and conflict exist. Identification of conflict was extended beyond stakeholders, and in line with CPR key themes, included situations where narrative was in conflict with either established policies and legislation, or unofficial societal goals, outlined within the PCC itself.

Given the diversity of the PCC Commissioners, and of the institutions and organisations they represent, it is not surprising to find that the framings of the role of gas were equally diverse. Perhaps the most notable of these divergences were the relative framings of justice associated with future gas. As outlined in section 2.5, this research, in keeping with the PCC's own frame of reference, integrates three forms of justice that have featured in the literature on transition and social justice: (Jenkins et al., 2018; Bouzarovski, 2022; Hicks et al., 2022): namely, distributive, restorative, and procedural justice. There was some crossover among how these concepts were understood, but it was on the whole the case that the ministerial component of the PCC used all three (as described in chapter 7 and the paper), though mainly emphasising restorative justice, particularly historic injustices, and the need to use current resources to redress historic wrongs from the era of apartheid, and, more generally, from imperial dealings with the African continent. The influential organised-labour Commission representatives were neither consistently pro or anti gas, and their contributions reflect that they situated their

[4] Paper 1 is being prepared for submission, journal tbc.

narratives within the procedural and distributive justice framings. Those that were opposed to all gas development, made up of diverse stakeholder and sectoral sets, broadly framed their diverse arguments under the restorative justice umbrella. Finally, it was found that the ministerial component of the Commission regularly put forward policy preferences that were contrary to the Commission's own guiding principles, and signalled likely disagreement and conflict in the future.

In Paper 2,[5] I draw on critical resource geographies literature, particularly the works of Kuchler and Bridge connecting this literature to shale gas resource development. The paper seeks to connect shale gas resource estimates, with concepts outlined by Kuchler and Bridge (2023), specifically the politics of possibility, resource-making and (un)making framings of shale gas resource estimates, and their associated geo-imaginaries. The paper uses the "gatekeepers" of geoscientific knowledge, that is the DMRE, PASA, and the CGS, as the "core set", and the resource estimates produced by the EIA, de Kock et al. (2017), and PASA, as the basis of the critical analysis. The primary data is derived from an analysis of both documents published by the gatekeepers, and of media documents, that specifically reference shale resource estimates from 2017 – 2023. The paper also draws extensively on primary data from the interviews carried out during the entire research project.

It was found the initial US EIA estimates set in play a stream of national resource politics and political strategizing. The EIA estimates have kept a high profile throughout the period from 2011, and have been reproduced repeatedly by the gatekeepers, and in the media, even though both the de Kock and the PASA figures in theory have superseded them. The uncertainty in the estimates was found to be used as justification for the mobilisation of resources, and these "gestures" were found to feed into politics of possibility. The use of resource estimates in the framing of geo-imaginary horizons were largely centred around energy security and economic development, and embodied preferable comparisons with other countries. The de Kock report radically took the volume out of the resource estimates with a much lower range, opening up and supporting existing counternarratives to the resource politics of the government. However, the government and its agencies largely omit the de Kock estimate and its greater grounding in reliable knowledge for various reasons, notably to maintain the politics of possibility, in order to sustain the uncertainty in other bigger figures, and as a means of political strategy and narrative control. The PASA estimates appear to be an attempt to acknowledge that the US EIA estimates may be too high, and to a degree accommodate the de Kock generated counternarrative critique, but without radically shifting the scale of the resource estimate (it's less than a 50% reduction). This figure therefore

[5] This is currently a working paper. Complete excluding journal-specific submission requirements

represents a continuity from the EIA estimates rather than a break from them and in being used as part of the recent competitive release of the shale gas concessions is continuing to support a speculative politics of resource potential.

In Paper 3,[6] I use the key themes outlined in section 2.2, that is to say 1) actors; 2) regulatory, legal and institutional frameworks; 3) policies; and, 4) knowledge This provided a structure to assess the groundwater governance arrangements relating to potential unconventional oil and gas development in South Africa. The paper draws extensively on CPR literature, specifically groundwater governance literature, both as a means of addressing the paper's specific aims and objectives, and to identify existing legislative, regulatory, and institutional frameworks and mechanisms, and to provide a critique of their relative strengths and weaknesses, thus addressing Research Question 3. The methodology involved a global review of groundwater governance literature, which was then applied to the South African context, and drew on interview data and on observations and interactions of stakeholder events carried out throughout the course of the research project.

Key findings of the research included: 1: the need for continued stakeholder engagement, and for the outcomes of these processes to be embedded in the policy- and decision-making processes: this latter aspect is a recurring theme through the thesis; 2: the necessity for detailed groundwater-specific regulations to be drafted as soon as possible, (the delay in developing formal policy has already been alluded to in this chapter, and in its absence, there is a risk of a policy vacuum having a deleterious effect on groundwater management);and, 3: there are significant governance gaps, particularly regarding regulatory and institutional capacity. Budgetary constraints could hamper effective CPR governance, though this might to some extent be offset by the establishment of effective, formalised institutional communication channels.

Although it is not claimed to be an entirely novel approach, addressing a specific example of CPR governance, and extrapolating these findings to answer research question 3 (section 7.4), sets out an effective methodological approach to the assessment of undetermined governance arrangements, such as those of shale gas resource development in South Africa. All the key themes are relevant to governing shale gas resources, even though, as was pointed out in section 7.4, they would constitute an atypical CPR, providing insight into potential or likely challenges that would emerge in the event of resource development. This would serve as a warning to mitigate these challenges, as well as providing potential solutions.

Before the three papers, the thesis includes a literature review (chapter 2) and a methodology discussion (chapter 3). The papers themselves include both elements, but they are specific to

[6] Published in *Hydrogeology* (Hemingway and Gormally-Sutton, 2023).

the papers, and necessarily abridge the material on which they are based. So the literature review chapter of the thesis situates my research within the wider academic literature, and also provides an overview of the scholarship that has influenced this research. The methodology chapter outlines in more detail than the papers the various methodological approaches used in the course of this research, and also describes the fieldwork element of the project, and how this was integrated with the data. The methodology chapter also contains a discursive account of my reflections on these methodological approaches, and an acknowledgement that research is a process which may need to be stopped before it is finished - if it ever is in a project of this nature.

1.4. COVID-19 impacts

COVID-19 had a significant impact on this research in a number of different ways. It is necessary to outline these given the way they shaped the research and its outcomes. In late 2019, I had my initial outline for the research established, and plans in place for the upcoming fieldwork, including arranged meetings, site and institutional visits, and a broad outline of the fieldwork as a whole. My flights were booked for the week after the initial lockdown restrictions were put in place in the United Kingdom. What followed immediately after lockdown was a period of uncertainty. Initially, it was concluded it would be preferable to keep to my initial plans, and hope to pick them back up at the earliest opportunity. When it became apparent this would not be a short-term solution, plans were made to redesign the project to reflect the fact that it might be necessary to do the entire research under lockdown conditions. This inevitably meant returning to the drawing board to a large extent.

It was at this juncture, after months of indecision, where the document analysis and online interview elements of the thesis were introduced. The online interview process was challenging. Given the circumstances, many people I had initially arranged to meet were no longer actively working, were working from home, or generally had more pressing matters of their own to deal with than talking to me. This challenge was compounded by the remote location of some of my intended participants, with technological issues being a frequent occurrence, as well as the general unfamiliarity with technology. This made data collection difficult, for example, I have interview data collected over the phone, recorded on my elderly device, spread over several files owing to the numerous times the connection failed. These issues not only made collecting and organising data problematic, they also inevitably had an impact on the enthusiasm of the participants, and their willingness to be involved in the project.

The uncertainty persisted, and continued to impact the outline of the work. When lockdown restrictions were removed, but travel bans remained in place, I remained enthusiastic about the potential to conduct the overseas fieldwork, but specific planning was obviously impossible. This resulted in many of my online interviews being left open-ended, with the hope that further in-person work would be possible. When the travel ban was lifted, I acted in haste to get to South Africa out of concern travel bans would be immediately introduced. In the 8 days between the travel ban to South Arica being lifted and my arrival in RSA, there was little time to organise a detailed itinerary, given the need to put my domestic arrangements in order, and the various obstacles needing to be overcome to be able to travel (vaccine certificates, apps, government forms etc.). This meant I arrived in RSA comparatively unprepared, a fact that was compounded by the time of year (late November), and the usual winding-down / tidying up loose-ends, that this period entails for many people. Further, the duration of the fieldwork was necessarily reduced from 6 months to 3 months owing to time constraints on the project.

Prior to my fieldwork I was also myself unwell with COVID-19, and bedridden for the best part of a month, with a similar period of time required for recouperation, though thankfully with no lasting health consequences.

My external supervisor from the British Geological Survey was also severely unwell, and unable to work for all of 2020 and 2021, and only returned to work on a very restricted part-time basis in 2022. This had a negative impact on the research. Firstly, as she and I had developed a productive working relationship, which was lost, and secondly, wider input from the BGS was also largely removed. Efforts were made to arrange a replacement supervisor, but the specific circumstances, and the general upheaval at the time, meant this was not possible. This limited my access to geoscientists that formed the basis of much of this research, and meant I had to establish new relationships with geoscience professionals, which is far from ideal half-way through a research project.

Finally, the delays to the project caused by COVID-19 had a substantial economic impact. My initial funding was for 36 months, with only a 3-month extension available. This meant the funding expired during my fieldwork. On returning from RSA, it was necessary to get a job. I chose to remain on the full-time degree programme, which in hindsight, may not have been the correct path, as it soon became apparent that working alongside writing up the thesis was a significant challenge. This was compounded by the general cost of living crisis, and repercussions from the so-called “mini budget”, which meant I had to increase my paid employment to nearly full-time to make ends-meet.

Working from home, and then not being in a financial position to be able to return to the university office when this became possible, was difficult and the absence of the collegiate environment, and the benefits this brings to research, was unsatisfactory.

The result of all these factors is reflected in the overall design of the thesis, with its combined desk-based, interview, and fieldwork aspects. Getting to South Africa was a challenge, and the limited time I was able to spend there was somewhat restricted, but I believe its value is reflected in the project. And although the decision to persevere with the original design has meant it has taken longer than anticipated, It is to be hoped that the outcome justifies the approach.

2. Literature Review

The three papers which constitute the main body of this thesis drew on a wider academic literature, so the purpose of this review is to situate the research in this material. The review starts with an overview of the common-pool resources literature, then follows a review of groundwater governance literature and its relevance to shale gas resource development. The common-pool resources literature provides the broad theoretical frame for the thesis as a whole, a framing that is complemented with concepts derived from Science and Technology Studies (STS), energy transitions, and resource geographies literatures, which constitute the latter part of this review. The review concludes with a brief summary integrating the literature review and the research aims and methods. The literature review will also highlight how the identified works have contributed both directly and indirectly to the thesis.

2.1. Introduction: the context and history of common-pool resources and environmental governance

In 1968, Garrett Hardin published the influential essay *The Tragedy of the Commons*, in which he describes a theoretical situation when common-pool resources (CPRs) become over-exploited by individuals for immediate personal gain, despite the eventual outcome of their actions being to cause harm not only to the other users of the resource, but ultimately to the individuals themselves. Hardin applied a rough mathematical logic to his argument: that because any gain from the common-pool resource was individual, but losses were shouldered collectively, the “positive utility” outweighed the “negative utility” and therefore it is inconceivable that any *rational* stakeholder using a CPR would do anything other than try to maximise their gain, despite the impending tragedy (Hardin, 1968). When revisiting his work, Hardin concluded that the *tragedy* could only be avoided by having a managed commons, and that this can be achieved through either “socialism or the privatism of free enterprise” (Hardin, 1998. P. 683), though Elinor Ostrom, in her book *Governing the Commons*, refutes this, and instead approaches the predicament from a different angle. Rather than applying a prescriptive method, such as the dichotomy offered by Hardin, Ostrom instead asked the question: how is it that “some individuals organize themselves to govern and manage CPRs, and others do not [?]” (Ostrom, 1990. P. 27). This inductive approach led to Ostrom outlining her set of *design principles*, which could lead to equitable and sustainable utilisation of CPRs, and which have also been credited with laying the foundations for what we now consider environmental governance (Forsyth and Johnson, 2014).

Environmental governance began to gain traction in the 1990s, and developed into what Villholth and Conti describe as a “conceptual umbrella” for themed environmental challenges, for example climate governance, or water governance, but also as a way to address specific challenges, notably the international legal framework for addressing Chlorofluorocarbon (CFC) emissions (Villholth and Conti, 2018. p. 7). The concept of environmental governance has since evolved to include different spatial scales *e.g.* transboundary and regional governance, and has begun to include a wider variety of non-state actors, and to include normative concepts, such as the United Nations (UN) Sustainable Development Goals (Rosenau, 1997; Villholth and Conti, 2018; Winchester, 2009).

Environmental governance has thus become a wide-reaching subject, and its theories and practices will be discussed later in the chapter, but it is the concept of groundwater governance (GWG), a sub-category of environmental governance, that will be the immediate focus, and more specifically, how groundwater governance is being applied in the wake of a burgeoning unconventional oil and gas (UOG) industry. This section will begin by introducing groundwater governance, including a brief history of the discipline, and identifying the key themes that dominate the subject’s discourse, before providing a more specific review exploring the connection between the UOG industry and groundwater. The review will adopt a global perspective of GWG in the first instance, before becoming more focussed when exploring GWG and the UOG industry, with particular attention being given to South Africa, although other perspectives will be introduced where appropriate.

2.1.1. Introduction to groundwater and groundwater governance

It is estimated that groundwater constitutes over 30% of the world’s freshwater, and 98% of its liquid freshwater (NGWA, 2019). It is an immensely valuable resource, both as an essential for human survival, providing an estimated 2 billion people with drinking water, and an unquantifiable economic asset, supplying over 40% of all irrigation demands worldwide (Ross, 2016). It also has a unique environmental function of acting as a “buffer” in the hydrological cycle, by converting irregular recharge into more stable baseflows and spring flows, necessary to sustain many different ecosystems, including rivers and wetlands (Murray et al., 2008; van der Gun and Custodio, 2018 p. 391). Intensive groundwater use, however, is a relatively new practice, made possible by technological advances that have led to more cost-effective and efficient methods of groundwater abstraction. This development has been of huge economic and social benefit, providing rural and urban areas with a water supply that is often of a high quality, and one which is less susceptible to seasonal and periodic occurrences such as drought (Kemper, 2004). But demand for groundwater is growing, and increasing abstraction, coupled with the ever- present threat of pollution by both diffuse and point sources (*e.g.* pesticide or fertiliser application and industrial spillages) is, in many parts of the world, threatening the sustainability of groundwater use, and at the same time damaging groundwater dependent ecosystems.

This rapid, and often unregulated, development of the use of groundwater has in many cases outpaced the efforts to govern it. This is partly because of the inherent qualities of groundwater, notably its invisibility, its often slow rate of flow, and its widespread distribution, [7] all meaning that it tends to be seen as a common-pool resource. The result has often been weak or fragmented governance (GEF-GD, 2016; Villholth and Conti, 2018) which is now widely recognised as the underlying cause of the unsustainable and inequitable use of groundwater, and of many elements of the general groundwater crisis (Mukherji and Shah, 2005; OECD-Principles on Water Governance, 2017; Water.org, 2019).

The importance of groundwater itself, of its equitable and sustainable use, and of the protection of ecosystems dependent upon it, mean there is the need for effective governance. Inevitably therefore GWG is receiving increasing international attention. Perhaps the most notable developments are the collective works conducted by the Global Environment Facility (GEF), and the book *Advances in Groundwater Governance* (2018), edited by Karen G. Villholth et al.

(See Paper 3 for a detailed overview of these works, and an explanation of the definitions used, and distinctions made in this review (*e.g.* governance vs management).

2.2. Key themes

Throughout the course of the *groundwater governance Project*, a number of key elements emerged as fundamental to GWG, the findings of which have been widely reproduced (see de Chaisemartin et al., 2018; Mechlem, 2016; van der Gun and Custodio, 2018). These elements may broadly be categorised as: 1: actors; 2: regulatory, legal and institutional frameworks; 3: policies; and, 4: knowledge, information and science. These key themes, directly applied in the methodology and qualitative analysis in Paper 3, and also feed into the wider thesis. The mapping of themes 1, 2, and 3 (for both groundwater and gas) formed the

[7] This triad of characteristics is described by Villholth and Conti as groundwater's ISD signature (Invisible-Slow-Distributed).

basis of the exploratory research for the entire project (see section 3.1), and were informative categories in the discourse analysis of Papers 1 and 2 (see section 3.3.3). The following section breaks down these four categories to establish what they constitute, what deficiencies and opportunities they face and present, and how they tie in with the research questions (section 1.2).

2.2.1. Key theme 1: actors

Top-down Governance and Stakeholder Participation

There are a number of actors involved in the abstraction, management, and governance of groundwater, including the private, public, and third sectors and they operate at a number of different scales of governance, from local to global (GEF-GD, 2016; van der Gun and Custodio, 2018). So many actors present an obvious challenge to governance, since actors' motives and desired outcomes are varied, and the connections between different stakeholders and associated benefits (*e.g.* cost and knowledge sharing) are often limited (Megdal et al., 2017; van der Gun and Custodio, 2018). To overcome these obstacles, or at least mitigate their impact, a number of different approaches to GWG have been tried, some of them effective, some less so. A few examples will now be discussed.

Many of the overall policies relating to GWG are formulated by government departments, with state-level governance determining legal and regulatory frameworks, outlining policies, and setting the rights and obligations of the various stakeholders. Although it is widely agreed that some sort of centralised organisational body is necessary (GEF-GD, 2016; Molle et al., 2018), purely prescriptive top-down approaches have been shown to have limited success.[8] Reasons for such failings are various, and often dependent on local context, but common themes include (but are not limited to) government departments being ill-equipped or underfunded, which leads to poor implementation and enforcement of policies (Megdal et al., 2014; Molle et al., 2018); governments having poorly defined or "fuzzy" mandates (van der Gun and Custodio, 2018; van der Gun et al., 2016 p. 392); and central agencies lacking stakeholder trust and having poor accountability (Pereira et al., 2005; van der Gun and Custodio, 2018). These problems, along with the fact that groundwater abstraction and management often have a history of self-regulation, and an associated indifference to prescriptive governance approaches, go some way to explaining why such approaches have limited success (GEF-

[8] Some examples of the failures of top-down governance approaches can be seen in Kuzdas et al. (2015) Sustainability assessment of water governance alternatives: the case of Guanacaste Costa Rica, and Rica et al. (2012). Analysis of the emergence and evolution of collective action: an empirical case of Spanish groundwater user associations.

GD, 2016). It is these problems that have led to the adoption of other modes of governance, particularly ones that include a bottom-up element, in the form of stakeholder participation.

Stakeholder participation is increasingly becoming seen as a way to improve the efficacy of environmental governance. It was one of Ostrom's *Design Principles*, and can improve perceptions of legitimacy (Eden et al., 2016; Foster and Garduño, 2012) and compliance with policy (de Chaisemartin et al., 2017; Megdal et al., 2017). There are numerous forms of stakeholder engagement, but Ostrom (1991) suggests that successful stakeholder participation is at least in part dependent on the individuals involved determining the means of engagement, and other examples of successful engagement have occurred when individuals have organised into groups, such as committees or Water Use associations (WUAs) (GEF-GD, 2016).[9] However, stakeholder participation alone is not sufficient if an holistic governance approach is to be achieved,[10] (the limitations of stakeholder engagement in the South African context of shale gas development and GWG are discussed further in section 3.4.5). To mitigate these shortcomings, a number of schemes that incorporate both top-down and bottom-up approaches to governance have been enacted (see Paper 3).

2.2.1.1. Challenges of governing the subsurface

There are many challenges that face the actors involved in GWG, and actors involved in governing the subsurface. These include problems of awareness and knowledge-production, stakeholder engagement challenges, and governmental challenges. Further, there are some broad misconceptions about the threats facing groundwater, and how these can be mitigated alongside shale gas development in order to ensure its sustainable use (Eden et al., 2016; Foster and Garduño, 2012; Megdal et al., 2017; Villholth and Conti, 2018). Stakeholder engagement, moreover, presents a number of different and unique problems because, since coordination between actors is essential, there is a persistent and pervasive challenge to engage with stakeholders in the first place, and then to embed their participation into the governance framework (GEF-GD, 2016; Mott Lacroix and Megdal, 2016). Mistrust and rivalries between actors, and over and underrepresentation of certain groups are also a challenge (GEF-GD, 2016; Jacobs and Buijs, 2011; Villholth and Conti, 2018). And there are a number of governmental challenges that need also to be addressed, notably resource-

[9] Some successful implementations of stakeholder engagement approaches include Guanajuato, Mexico, where groundwater-user committees (Wester et al., 2011) have been credited with reducing groundwater abstraction by 60 percent over 10 years (OECD, 2013), and via aquifer contracts in Morocco (Closas and Villholth, 2016).

[10] Assessments of the Mexican COTAS project and Participatory Irrigation Management Schemes in India both concluded self-regulation alone was insufficient (GEF-GD, 2016; Wester et al., 2011).

allocation, clarity of mandates, and transparency in accountability. In some instances, however, effective stakeholder engagement and effective communication channels may be able to compensate for a lack of resources, as may technological advances (section 7.4).

This has led to the development of concepts such as adaptive governance[11] (*e.g.* Knüppe and Pahl-Wostl, 2012; Mott Lacroix and Megdal, 2016; Ostrom, 2007 and others), that enable governance approaches to align with *in-situ* realities, such as the socio-economic or hydrogeological circumstances, and to be represented at the appropriate geographic level *e.g.* local or national scale. Although navigating what can be described as "wicked" problems [12] like GWG and shale gas resource development, that is to say, problems with complex interdependencies, is difficult, it also presents opportunities, and these will be the final part of this section.

2.2.1.2. Opportunities

Engagement between actors and different levels of governance presents opportunities to foster dialogue between stakeholders, both at the inter-state level through, *e.g.* transboundary aquifer arrangements, and at intra-state level between *e.g.* the private sector and government departments. It can facilitate institutional reforms, improve accountability and transparency (Villholth and Conti, 2018), and strengthen trust between different actors, all of which in turn can be valuable by encouraging mutually beneficial outcomes such as the sharing of associated costs and information.

2.2.2. Key theme 2: legal, regulatory and institutional frameworks

Legal, regulatory and institutional frameworks are crucial for effective environmental governance. They define the rights and obligations both of users and of administrative authorities, and form the basis of more refined policy development. It is clear that the starting point for any legislation must be to determine who owns the resource, and then to outline what

[11] The Stockholm Resilience Centre define adaptive governance as "…an evolving research framework for analysing the social, institutional, economic and ecological foundations of multilevel governance modes that are successful in building resilience for the vast challenges posed by global change, and coupled complex adaptive social-ecological systems" (Stockholm Resilience Centre, n.d.)

[12] Defining wicked problems is problematic; as Rittel and Webber (1973) put it: "…the information needed to understand the problem depends upon one's idea for solving it. That is to say: in order to describe a wicked-problem in sufficient detail, one has to develop an exhaustive inventory of all conceivable solutions ahead of time."

aspects of resource use and protection need to be subject to regulation (Burchi, 2018; Chaisemartin et al, 2017; Mechlem, 2012). Legal frameworks work at different levels, from the local, to intra-state and inter-state, and legislation must also be designed in the light of institutional capacity to implement, regulate, and where necessary enforce existing and developing regulation, and assess the impact this may have on existing or customary rights.

2.2.2.1. Resource ownership and stewardship, legal implementation and enforcement

The development of groundwater legislation has seen a shift from assuming that groundwater resources are inextricably linked to land ownership, to a general recognition that they are public property under the stewardship of the state. There are different approaches to groundwater legislation. The most basic is the *rule of capture*[13], adopted by *e.g.* Texas (USA), Pakistan and India, and which is also applicable to petrochemical resources, an approach whereby landowners are entitled to exploit resources as they see fit within their territorial boundaries: an approach which is widely criticised as it seriously handicaps most governance efforts. Against this is a more centralised control of groundwater resources in which all existing water rights are transferred to the state (Burchi, 2018). This transition from private to public ownership is largely due to a shift in perceptions: an acknowledgement that groundwater is a finite resource (Prasad and Kazama, 2023), and that groundwater resources, although common-pool, need to be treated not as open-access resources, but as a public good, which inevitably means state intervention in its use (García and de Vries; GEF-GD, 2016; Prasad Pandey and Kazama, 2023; Mechlem, 2012). The South African Constitution (1996) embodies this principle to both mineral and water resources. But despite widespread agreement that it is necessary to separate private property and resource rights, legislative difficulties can arise if they infringe on existing customary law or existing practices, and in such cases compensation or other reparatory mechanisms may be necessary, and when new legislation goes against existing customs, its implementation can be difficult to achieve[14] (Burchi, 2018; Llamas et al, 2015; Mechlem, 2015; Roth et al., 2015), and is frequently cited as a reason for non-compliance (GEF-GD, 2016; Llamas et al., 2015; Zubari, 2013).

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[13] Precedent was set for the rule of capture in Texas in 1904 in the *Houston & Texas Central Railway Company v. East,* 81 SW 279 and recent legislation has reinforced this in the 2012 case of Edwards Aquifer Authority v. Day, 369 SW 3rd 814. See Burchi (2018) for a detailed history of the rule of capture in Texas.

[14] This further highlights the need to include stakeholder participation as a founding principle of GWG, but also introduces the idea that its inclusion should be built into any legislative framework, for example by specifically reserving consultation rights to interest groups *e.g.* water users' groups or environmental interest groups (Burchi, 2018).

Historically, legislation on groundwater has been focused on the licences involved in its abstraction, including drilling permits, volumetric abstraction limits and rates, and basic point-source pollution prevention measures. This approach is increasingly being complemented with laws designed to incorporate the protection of groundwater-dependent ecosystems, and with laws that acknowledge the temporal aspect of groundwater and its recharge, with corresponding legal requirements determining technical aspects of groundwater monitoring, and governance aspects like stakeholder participation (Burchi, 2018; de Chaisemartin et al, 2017; Mechlem, 2012). In addition, social elements are increasingly being introduced into legislation, and, for example, the RSA Constitution (1996) holds as a fundamental human right to an environment that is not harmful to the health or wellbeing of its citizens (Mechlem, 2016).

The GEF found enforcement of legislation to be weak, or in many instances unsatisfactory (GEF-GD, 2016). They identified several reasons for this, including, but not limited to, a lack of capacity within governments to effectively manage the challenge of the many aspects of groundwater legislation, from issuing drilling permits to monitoring groundwater use. There was also a focus on the water-users for lack of compliance, which was in some cases due to the prohibitive costs associated with compliance, and in others to the presence of a social culture of non-compliance (GEF-GD, 2016; Zubari, 2013). Again, the solutions offered by the GEF and others are to raise awareness of the importance of groundwater, and to encourage stakeholder participation in decision making, implementation and enforcement. A more detailed methodological approach to implementing legislation is provided by Garduño in the 2011 FAO report *Water Rights Administration - Experience, Issues and Guidelines* which sets out a series of steps to be followed: these include establishing capacity prior to the implementation of legislation, and the simultaneous drafting of regulation with its corresponding implementation tools, thereby creating a feedback mechanism to improve efficiency. In addition, feasibility studies and adequate transition periods between drafting and introducing new legislation are necessary and Ostrom (1990), also suggests the use of graduated sanctions for rule violations.

2.2.2.2. Opportunities associated with improved legal frameworks

As Foster and Garduño (2012) have shown, legal reform is not an instantaneous process, but when it is done correctly it can be extremely beneficial. By discarding outdated regulation, ensuring that new legislation minimises policy fragmentation, and introducing enforceable laws that incorporate modern socio-ecological goals and aspirations, it can adopt the current best technological practice to achieve these ends (Conti and Villholth, 2018; Foster and Garduño, 2012). These points are relevant to the legislation of shale gas resource development, and to the corresponding groundwater and environmental legislation, as many new pieces of legislation are inevitably going to be drafted. And international legislative agreements provide an opportunity for fostering dialogue and conflict resolution between states.

2.2.3. Key theme 3: policy

Although inherently interconnected, there is in practice a distinction between laws, policies, and management strategies. Legislation defines principles, such as the no-harm rule or equitable utilisation, and provides a framework within which policies must be developed: but it is a slow process, and developing and enacting laws (or ratifying in the case of international law) tends to take a long time (often years, and in some cases, decades[15]), and once in place are difficult to amend. Management strategies on the other hand are location-specific and are the tools and activities used to achieve policy, so it follows that it is policies that are the link between the two. Policies set goals, they represent societal preferences, such as economic growth or environmental sustainability, and are therefore inherently political, but they can be implemented relatively quickly, and have the potential to be flexible. Policies also tend to reflect societal structures, such as a preference for top-down or bottom-up approaches (see section 6.3.3) (GEF-GD, 2016; Varady et al., 2012). Policies involve goals, but they also reflect preferences, principles and the agreed processes to achieve these ends: so, for example, the UN Sustainable Development Goals have indicators and targets embedded in their framework as well as principles, many of which have precedents in law (such as the no-harm principle); domestically, though, it is sometimes necessary to build principles into policy prior to specific legislation being enacted. Two examples of this are the “the polluter pays” principle,[16] and the “precautionary principle”[17] (GEF-GD, 2016; Varady et al, 2012).

[15] *e.g.* the *Watercourse Convention* which entered into force in August 2014, seventeen years after its adoption by the UN General Assembly in 1997 (UNECE, 2021).

[16] *“The ‘polluter pays’ principle is the commonly accepted practice that those who produce pollution should bear the costs of managing it to prevent damage to human health or the environment.”* The polluter pays principle provides examples of how policy design can be used in different ways to address potentially harmful activities, as seen by policies such as the carbon tax, or carbon trading schemes designed to force companies to internalise the cost of their activities (Schwartz, 2010).

[17] The definition of the precautionary principle was outlined in the 1990 Rio Convention as: *Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*, however different definitions have since been applied according to circumstance since then (HSE, n.d.).

2.2.3.1. Fragmented governance, trade-offs and boundaries

One significant challenge to effective groundwater policy is that of fragmented governance, though given the complexities and the myriad of component parts that constitute GWG, it is not surprising that there is at least some degree of fragmentation. But fragmented governance is likely to lead to incoherent policies or competing objectives and/or obligations (Nelson and Quevauviller, 2016; Mechlem, 2012). Examples of this would be when different sectors within government have different mandates *e.g.* the agriculture and mining sectors, or where there's inter-agency fragmentation so that water quality gets addressed separately from water availability. Fragmented governance also increases the likelihood of oversight through misunderstanding and miscommunication, and it can lead to a lack of clarity about *who* is ultimately responsible for *what*, which may result in waste and inefficiency owing to overlapping responsibilities (*e.g.* through duplication) (GEF-GD, 2016). Some degree of fragmented governance is unavoidable when working with such complex political, social and environmental systems as are involved in GWG, and in such circumstances it has been recognised that it can actually have some positive outcomes, for, as Blomquist and Schlager (2005) argue, efficient distribution of responsibilities can potentially create more responsive and efficient governance systems. As with legislation, though, it is imperative that sectoral linkages are not ignored, and that fragmentation does not embed contradictory rights and obligations into the governance system (Cummins, 2012; GEF-GD, 2016).

Trade-offs play a key part in policy development, and some trade-offs are inevitable because of conflicting objectives, and others become necessary owing to limited resources. It is the job of policy makers to determine what will take priority, and how to mitigate the deleterious consequences of any decisions. Examples of trade-offs that face policy makers include whether to favour short-term or long-term goals, or which sector of government to prioritise. In the case of groundwater, one common trade-off is the balancing of economic and environmental objectives (Conti and Villholth, 2018; Janzwood and Millar, 2022), and there are also social trade-offs such as how to balance existing water rights and environmental justice (Rica et al., 2017). In addition to intersectional trade-offs, decisions must also be made within sectors, when, for example, allocating water rights within the agricultural sector. Pragmatic approaches have been adopted to deal with limited resources that necessitate trade-offs, but it is often the short-term objectives that take priority (GEF-GD, 2016). There are different reasons for this short-termism, though a cynical conclusion might be that policy-makers choose the option with the most immediate benefit to themselves.

Ostrom (1990 p. 91) specifies in her *Design Principles* that: "Individuals or households who have rights to withdraw resource units from the CPR must be clearly defined, as must the boundaries of the CPR itself." This is problematic in the case of water, because accurately mapping aquifers is difficult: it is time consuming, expensive, and requires skill (Fetter, 2011), with the result that many aquifers are poorly mapped or not mapped at all. To work according to Ostrom's principle, therefore, policy-makers have to define boundaries, and then create governance units that correspond to these (*e.g.* the EU Water Framework Directive River Basin Management Strategies); but even where boundaries are reasonably clearly defined, the governance units involved in policy decisions are generally not well matched, and do not readily map on to aquifer boundaries (Cash, 2006; Moss, 2012; Varady, 2012).

To overcome the boundary conundrum, the GEF promote the adoption of holistic governance approaches to mitigate mis-fit governance systems, (GEF-FFA, 2016; GEF-GD, 2016), and alongside this they reiterate the need to adopt the governance principles already identified in this report, notably stakeholder participation, accountability and transparency (GEF-GD, 2016; Varady et al., 2012).

2.2.4. Key theme 4: knowledge, information and science

Knowledge gaps create a challenge for effective common-pool resource governance. From a groundwater science perspective, such gaps could include their integration with other systems, such as groundwater dependent ecosystems, or between deep and shallow aquifers (Eamus and Froend, 2006; Jaxa-Rozen et al., 2015), while from a socio-ecological perspective, gaps could include how many people rely on the resource (Foster and Garduño, 2012; Villholth and Conti, 2018). Identifying knowledge gaps, or identifying knowledge that is impractical to obtain is therefore an essential preliminary for effective governance (Milmann et al., 2020; Villholth and Conti, 2018).

It is necessary also to establish baseline data, *e.g.* water quality, against which to measure any changes introduced to a *common* (Pietersen et al., 2016; Varady et al., 2016). This also applies to non-environmental variables like income distribution, or socio-scientific issues such as health data of people reliant on a CPR (Ostrom, 2010). While detailed scientific assessments of various interdisciplinary baseline requirements are beyond the scope of this research, they need to be mentioned owing to their fundamental importance to effective commons governance (Ostrom, 1991).[18] How specific geoscientific knowledge is generated is addressed in Paper 2, but, again, this information must be considered when establishing

[18] Specific baseline requirements related to shale gas resource development and groundwater are addressed in more detail in Paper 3, as are geo-scientific knowledge gaps.

commons governance arrangements. And, finally, who is actually generating knowledge is also significant: this is addressed in section 2.3.

How the available knowledge is used is also relevant to commons governance (Mott Lacroix and Megdal, 2016; Varady et al., 2016). Access to data can facilitate the more effective governance of CPR's, a facet of governance associated with stakeholder engagement, and its connections with "buy-in" and compliance (Agrawal et al., 2013; Jokonya et al., 2013). The often proprietorial nature of data regarding gas resource extraction, and the processes involved in its acquisition, are a matter for concern when relevant to CPRs, and need to be addressed through legislative and regulatory means where possible (Reeder, 2009).

The establishment of effective communication channels between stakeholders has also been identified as an effective means of improving CPR governance (Ostrom, 1991), so fragmented governance, as outlined earlier, should ideally be kept to a minimum (Mukherji and Shah, 2005; OECD-Principles on Water Governance, 2017). Some fragmentation is often unavoidable (Megdal et al., 2014; Molle et al., 2018), but effective inter-stakeholder communication channels can often mitigate the negative consequences of fragmented governance (Esterhuyse et al., 2019; Villholth and Conti, 2018). How these are established is necessarily locally-specific, dependant on a variety of socio-economic and socio-technical considerations, but mechanisms such as polycentric governance structures[19] have been proposed as an effective means of embedding inter-stakeholder communication mechanisms (Pietersen, 2021).

2.3. Science and Technology Studies, knowledge, controversies, and the core set

It was early apparent that a broad theoretical framework would be required to inform research of shale gas development and governance in South Africa, as well as to understand the complexity of the topic, and its interactions between different disciplines. STS provided this theoretical starting point.

Science and Technology Studies is a relatively modern academic discipline which seeks to look at the relationships between science, technological systems, and society, and belongs in a long intellectual tradition of enquiry about the nature of scientific knowledge. It is, therefore,

[19] An interactive governance model that can facilitate effective stakeholder interconnections both vertically through institutional levels (e.g. between local government, central government and supranational institutions) but also horizontally between stakeholders at the same institutional level thereby improving the transmission of information, and effectiveness of institutional response (Cash et al., 2006; Ostrom, 2010).

a multidisciplinary approach that includes, but is not limited to, historians, sociologists, and natural scientists, and goes some way to bridging the gap between what C.P Snow notoriously described in his 1959 Rede Lecture as “The Two Cultures” of humanities and natural sciences, and their apparently irreconcilable approaches of interpretive inquiry and rational analysis (Edge, 1995; Ortolano, 2011). The discipline gained momentum in the early 1960s following the publication of Thomas Kuhn's iconoclastic work *The Structure of Scientific Revolutions* (1962). This questioned a “Whig” interpretation of the history of science, which took it for granted that that science was a cumulative, linear, process, in which knowledge develops by refining and enlarging what had gone before: famously, summed up 1675 by Newton in in his comment: "If I have seen further, it is by standing on the shoulders of giants." Kuhn proposed instead the notion of “paradigm shift”: [20] that from time to time there occurred, sometimes dramatic, recasting of what had become generally accepted as universal and unchanging knowledge, and replaced it by new ways of seeing and understanding. This led Kuhn to conclude that knowledge was, at least in part, a product of the scientists' social context, and this in its turn raises the question of how, if scientific facts and discoveries are indeed at least partially socially constructed, these insights can be applied to the social sciences, and to those constructs in which scientific ideas have become embodied, such as law, policy, and governance (Naughton, 2013; Sismondo, 2010).

Building on Kuhn’s work, science and technology have increasingly come to be seen as socially and politically embedded ventures (see *e.g.* Bijker et al., 2012). As a result, STS has started explicitly addressing matters of policy and politics, and the social and ethical implications of ongoing scientific and technological developments (Hackett, 2007), rather than remaining bogged-down in the theoretical quagmire that characterised the “science wars”.[21] To engage with questions of, for example, governance, participation, and accountability, STS scholars are increasingly extending their scope beyond the academy, and engaging with scientists, engineers, activists, and other stakeholders involved in various capacities with science and technology (Hackett, 2007; Thorpe & Gregory, 2010), and it is this approach that is of particular relevance to the study of unconventional resources in South Africa, and which

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[20] The “paradigm shift” concept put Kuhn at odds with the philosopher Karl Popper, whose book *Conjecture and Refutation* (1963), asserted that in order to practise *good* science, scientists must endeavour to refute rather than confirm their theories, whereas Kuhn asserted that the examples Popper provided were doing just that (Naughton, 2012; Rowbottom. 2011).

[21] The “science wars” were a theoretical debate largely arising from different reactions to Kuhn’s work, in which some members of the scientific community sought to discredit postmodernist theories relating to the social construction of scientific knowledge. The highlight of these *wars* was the infamous *Sokal Affair*: this was when the eponymous physicist/mathematician’s deliberately nonsensical paper *Transgressing the Boundaries: Toward a Transformative Hermeneutics of Quantum Gravity* (1996) was published in the academic journal *Social Text*, much to the subsequent embarrassment of the journal’s editors. That something is susceptible to parody of this sort does not, of course, invalidate it.

resonates with other aspects of my research (see key themes in Paper 3). Additionally, it is the long history of STS of dealing with *controversy* (see *e.g.* Collins, 1985; Gieryn, 1995; Martin and Richards, 1995; Nelkin, 1992; Pinch and Leuenberger, 2006; Sismondo, 2005), which make it well-suited to help frame the socio-political, socio-economic, and socio-ecological aspects of unconventional resource research, with its inherent knowledge gaps and power struggles.

The many controversies embedded in the shale gas debate are discussed at various points throughout the thesis, but it was the approach to studying controversy outlined in the STS literature that resonated during the developmental stages of my research. The central issue of scientific controversy for this research is the idea that when controversy occurs, *knowledge* is necessarily undetermined, and therefore subject to interpretive flexibility (Sismondo, 2010), (*e.g.* resource-making and geo-imaginaries, Paper 2). This interpretive flexibility is often negotiated between quite small groups of actors with specific expertise and interest in a particular debate, and so, by mapping scientific controversy, it becomes possible to identify key actors in the production of knowledge of a particular field, what Collins describes as the "core set" (Collins, 1981; Collins, 1981b; Sismondo, 2010). It was this theoretical concept that influenced the methodological design of this research: thus, in Paper 1, the Presidential Climate Committee was used as the framework for document analysis; in Paper 2, the "gatekeepers" of geoscientific knowledge were the basis of the discourse analysis; and, although to a lesser extent, in Paper 3, "actors" constituted one of the "key themes" of groundwater governance.

This idea of mapping controversy has its roots in the "Empirical Programme of Relativity" (EPOR), advanced in the 1970s by Collins. This was an approach that primarily involved identifying contested knowledge, which has the effect of bringing out a topic's flexibility, and in turn this transfers it from the natural to the social world, and then leads to the study of a "core set" of actors by using extended informal interviews (Collins, 1981; Pinch and Bijker, 1984). This broad methodological approach was applied in the interview selection process (see section 3.2) and adapted for the discourse analyses of Papers 1 and 2.

Finally, by studying how *knowledge* might be produced, and, in the case of shale gas resource estimates, its subsequent controversy, STS concepts provide a partial theoretical underpinning for the following review section which addresses energy transitions and resource geographies.

2.4. Energy transitions, and resource geographies

2.4.1. Background to energy transitions

The foundation for the energy transition was laid by the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the parties (COP) 21, which resulted in the Paris Agreement of 2015. This legally binding treaty, which received near-universal support from nation states, limits global warming to 2 degrees Celsius compared to pre-industrial levels (Kinley, 2016; UNFCCC-Paris Agreement). The process by which this will be achieved relies on the quinquennial submission of national plans for climate action, known as nationally determined contributions (NDCs), so signatories determine their own *pathways* for achieving carbon reduction according to individual socio-economic realities (Kinley, 2016; van Soest et al., 2017).

This non-prescriptive approach to socio-economic transformation and climate mitigation has inevitably resulted in numerous different approaches, *e.g.* the European Commission's (ECs) European Green Deal (EGD), and the beleaguered United States Green New Deal (GND). Moreover, beyond straightforward divergent pathways to lower carbon futures, there have emerged more substantive divergences, notably those relating to national and regional priorities, existing energy use, access to natural resources, and relative historical carbon emissions (Galvin and Healy, 2020; Hainsch et al., 2022; Healy and Barry, 2017). All of these feature prominently in South Africa's energy transition discourse, and the pathways to carbon reduction are also complicated by the contested categorisation of certain energy sources, notably gas and nuclear. This is exemplified by the EC's decision to classify certain investment in nuclear energy and natural gas as sustainable investments (a decision widely criticised by, *e.g.* Austrian Chancellor Karl Nehammer (Murphy, 2022)), which has global repercussions as it impacts on eligibility criteria for access to financial vehicles for funding sustainable development (Giamporcaro et al., 2023; Malerba et al., 2022; Yemelyanov et al., 2021).

So, although there is consensus on the need for a lower carbon future, the means by which this is to be achieved, and the expediency of the change, are very much dependent on national socio-economic, socio-technical, and geopolitical realities and perceptions (Blondeel et al., 2021). This, in turn, means imbalances in national wealth, regional inequalities, and existing means of energy production and its local socio-economic implications, become pivotal to the energy transition process. This fact has led to incorporating the concept of social justice as a fundamental aspect of the process, and the emergence of the "just transition" becoming central to mainstream climate change debate (Bouzarovski, 2022). This will be addressed later in this review.

2.4.2. Gas and the energy transition

The shale revolution, together with the advancement of high-volume hydraulic fracturing (HVHF) techniques have significantly altered the global energy system. Not only has it substantially increased the availability of natural gas on the global market, but the economic and energy security benefits of shale gas in the US have become an example which many other countries have sought to emulate (Bellani et al., 2021; Blondeel et al., 2021). The second point features in this research, where analogies feature in the national geo-imaginaries (see section 2.6) of shale gas development, linking shale gas with energy security, socio-economic benefits, and geopolitical opportunities (Papers 1 and 2).

The global development of the UOG industry has been controversial, particularly when HVHF extraction processes are involved. There have been some very public and widely-reported concerns about the burgeoning industry, ranging from cultural objections, such as the perceived racist politics that led to the routing of the Dakota Access Pipeline through reservation land (Hoffman, 2016; Kinchy et al., 2018), to environmental problems, notably potential groundwater contamination, surface water pollution, and fugitive methane emissions (*e.g.* Mooney, 2011; Schneising et al., 2014). There have also been objections to the planning processes, and to a perceived democratic deficit in the way in which energy policies have been advanced (*e.g.* Poole and Hudgins, 2014; Kinchy, 2016; Short and Szolucha, 2019), as well as questions raised about the water-use involved in UOG processes. It was not possible to address all these issues in this research, but they highlight the breadth of controversy associated with shale gas development, and provide a background to the inherent wide range of opinions among stakeholders that such controversies engender, and these form the theoretical basis for some of the methodological approaches adopted in this research.

One of the key ideas regarding the role of gas is that natural gas could be used as a “bridge” fuel between the current system of energy production which is heavily reliant on high-carbon fossil fuels, and a low-carbon system primarily reliant on renewable energy (RE) sources. (*e.g.* Kerr, 2010; Myhrvold and Caldeira, 2012; Zhang et al., 2016). The argument is that technological and economic limitations prevent the immediate widespread roll out of renewable energies (IRENA, 2020), and that natural gas provides a low-carbon, technically and economically viable means of transitioning towards a low-carbon economy, until such times as technological advancements in the RE sector enable it to meet energy demand (Zhang et al., 2016).

Many of these claims are contested. In particular, it is not clear that natural gas has in fact a significantly lower greenhouse gas footprint than coal (see *e.g.* Howarth et al., 2011; Hughes, 2011), and other aspects of the bridge-fuel concept have also been called into question, including whether gas would not actually be in competition with renewable energy sources, rather than facilitating their introduction (Delborne et al., 2020). It is also not clear whether investing in infrastructure for short-term energy policy is viable and would not instead result in gas becoming the "destination," rather the "bridge" (Delborne et al., 2020; Lawrence, 2020), and that such an approach could lead to "stranded assets".[22]

Part of the complexity of the stranded assets concept is that large national energy systems are prone to path dependencies, owing to their inherent complexity, and the institutional and infrastructural capacity required to maintain distinct energy systems (Blondeel et al., 2021). The same institutions, moreover, once established, may have significant influence on energy policy development (Swilling et al., 2015). This issue has been identified in South Africa, although in relation to the influence of the coal industry on government policy, often referred to as part of the national mineral-energy complex (MEC) (Lawrence, 2020; Swilling et al., 2015). These issues are explored in Paper 1, in which complex, and sometimes seemingly contradictory stakeholder alliances are formed (*e.g.* the coal and green lobby objecting to gas development).

(See section 4.2 for a detailed description of the South African energy context, including current energy mix, associated socio-economic data, and the socio-political context.)

That South Africa has no significant existing gas infrastructure [23] adds an economic consideration to its shale development ambitions. First, because the risk of stranded assets is obviously greater if the upfront costs are higher, and, second, because future economic realities could result in significant carbon lock-in if further investment to diversify the future economy mix is unavailable (Blondeel et al., 2021; Delborne et al., 2020). It is therefore a possibility that a nation such as RSA, with no significant infrastructure or legacy institutions, is in a position to "leap-frog" (Szabó et al., 2013) carbon-intensive gas development (Blondeel et al., 2021), and thereby avoid stranded assets and carbon lock-in. The complication here is the very high, though highly uncertain, shale gas reserve estimates (see Paper 2). Moreover, the stranded asset debate, although a necessary part of transition debate, is inherently an economic argument, a balance-sheet approach to policy which takes no account of alternative frameworks for policy decisions, notably innovation or social desirability (Sturgis and Allum,

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[22] "The Carbon Tracker Initiative (CTI, 2011) was among the first to publicly warn of the risks that hold for financial markets. Their notion of 'stranded assets' refers to the capital investment in fossil fuel infrastructure that could end up failing to be recovered over the operating lifetime of the asset because of reduced demand or reduced prices. There is an expanding research agenda on how fossil fuel assets may become stranded and the effects that this can have on markets" (Blondeel et al., 2021 p. 6).

[23] South Africa actually has a small but well-established gas industry, comprising ~3.8 GW installed capacity, from 6 open cycle gas turbines (OCGTs), a large gas-to-liquids refinery, and limited pipeline infrastructure.

2004; Williams et al., 2016), and can present policy decisions in a post-political manner (see Paper 2), that is to say, because something is economically sound, it is therefore correct. This inevitably ignores the nuances of the energy transition, notably justice (Williams et al., 2016), which is the focus of the next section of this review.

2.5. Just energy transition

It is widely accepted that the burden of climate change is not shouldered equally. Geography, regional inequality, historical injustice, gender, and poverty, all compound the effects of climate change, and result in certain groups being more profoundly impacted by its consequences (Musango, 2022; Sultana, 2021). Energy transitions pose the significant challenge of not replicating or amplifying these existing inequalities, and of not embedding fresh systemic injustices into new socio-technical regimes. To this end, it is necessary that the energy transition should move beyond the purely economic approach outlined above, and incorporate a more holistic approach to the reordering of existing socio-technical and socio-economic systems.

This "big picture" (Köhler et al., 2019 p. 3) approach to the energy transition has led to the incorporation of ideas from multi-disciplinary backgrounds, with the result that one key concept has emerged, and is now prominent in the transition discourse: that of "justice" (Bouzarovski, 2022; Wang and Lo, 2021). The inclusion of such an elusive notion has inevitably led to numerous definitions and interpretations, and its implementation is therefore necessarily tied up with individual or societal goals. Nevertheless, there have emerged certain themes within the justice literature that form the foundations of many of the recent interpretations and application of the energy transition. The term "just transition" originated in the US labour movement in the late 20th century, as a way of addressing the economic impacts faced by workers who were being made redundant as a result of policy shifts towards less carbon intensive means of energy production (Smith, 2017). The economic / labour aspect of the just transition remains one of its fundamental aspects (Carley and Konisky, 2020; Wang and Lo, 2021), but its scope has broadened significantly, and is now widely employed as a means to approach a multitude of social, political, environmental, technical, and spatial interpretations of justice. A comprehensive review of this literature is beyond the scope of the present study, but it is necessary to provide some overview to establish how the South African context is interwoven with various approaches to the just transition, and in turn, how these interpretations of the just transition have influenced this research.

The South African approach to the just transition is based on a framework of principles: those of procedural, distributive, and restorative justices (PCC - Just Transition Framework, 2022).

These are broadly what Wang and Lo (2021) categorise as an "integrated framework" approach, and are described by Jenkins et al. (2018) as the "three-tenet energy justice approach" to the energy transition. This framework is well established in the energy transition literature, and is derived from the environmental justice philosophical approach, summed up neatly by Jenkins et al. (2018) as:

> "The distribution of environmental hazards and access to all natural resources; it includes equal protection from burdens, meaningful involvement in decisions, and fair treatment in access to benefits" (Jenkins et al., 2018, p 67)

The economic aspect of the South African transition is particularly prominent, which is to be expected given the socio-economic importance of coal, as are the "three A's" – availability, access, and affordability (Jenkins et al., 2018 p. 67), which, again, is unsurprising given the national rates of both overall poverty and, specifically, energy poverty. So, the restorative justice approach, although not unique to South Africa, does carry particular significance owing to the singularly abhorrent socio-economic and socio-spatial policies sanctioned throughout the apartheid era, the outcomes of which still remain acutely relevant today (McCauley, 2018; PCC - Just Transition Framework, 2022). The principles of three-tenet approach inevitably overlap, but I will nonetheless discuss them in turn, and explore how they are applied within the outline of South Africa's just transition framework.

2.5.1. Procedural justice:

Procedural justice emphasises the need to approach the transition in a manner that enables representation and public participation, and which adheres to the principles of due process (Sovacool et al., 2017). In this respect South Africa is well-placed to establish an effective procedural justice mechanism, as these principles and procedures align with those outlined in the South African Constitution and are explicit in already existing legislation (*e.g.* the Bill of Rights, and the National Environment Management Act 107 of 1998). This embedded principle of representative and participatory governance has already proved to be of benefit, notably in the establishment of the PCC, a multi-stakeholder vehicle which is important in two ways: first, the broad expertise and representation of its commissioners (see table 4.1), and, second, its prestige status as a presidential body, which is instrumental in facilitating the inter-governmental cooperation needed throughout the transition (Connolly, 2022).

Since being established, the PCC has been an effective body. It has produced several detailed reports, and has hosted a number of stakeholder engagement events, in line with its commitment to transparency and public participation (Connolly, 2022). This participatory approach is important for a number of reasons. First, it gives voice to a diverse group of actors, which embeds a sense of fairness in the process (Jenkins et al., 2018), and it enables disparate groups to form coalitions, to further the objectives, and strengthen the position of those they represent where this might not otherwise be possible (Holland, 2017). Second, public opinion of the just transition is key to its success (Wang and Lo, 2021), so by facilitating a representative approach to the decision-making process, and by obtaining prior, informed consent for their policies, policy-makers can create a social compact, and consequently a social licence to operate (Connolly, 2022; Sovacool et al., 2017). Having this licence to operate is particularly relevant in the South African context, given the constitutionally-enshrined right of access to court. There have been several successful high-profile challenges to government policy, directly relevant to gas and to the just transition in recent years, initiated by civil rights organisations, unions, and advocacy groups,[24] demonstrating the need for social licence if protracted legal challenges to policy are to be avoided.

2.5.2. Distributive justice:

The distributive aspect proposed by the PCC is founded on two principles. First, the risks and opportunities of the transition must be shared fairly, an approach grounded in philosophical-justice reasoning (outlined by theorists *e.g.* Rawls, 1958), and well established in the justice literature (Sovacool et al., 2017). Second, the financial costs must be borne by those, who, as the PCC posit, are "historically responsible for the problem" (PCC - Just Transition Framework, 2022 p. 8). The latter aspect is a geo-political stance that is being used as a means to access international financing packages, and a position from which to negotiate their terms, and as such lies somewhat beyond the focus of this research. The former principle, however, plays a prominent role in how the use of gas and justice is being presented in South Africa. The mechanisms by which distributive justice is to be achieved focus primarily on the economic realities of the transition, and are intended to identify where (in both sectoral and spatial terms) jobs will be lost, and where they are likely to be gained. It is hoped that by adopting a transparent approach, it will be possible to mitigate harm, and distribute gain. In addition, the PCC identifies the need to upskill the workforce, and to engender an industrial approach that is more inclusive of historically marginalised groups (PCC - Just Transition Framework, 2022).

The spatial aspect of distributive justice is particularly relevant in South Africa. Owing to the ongoing spatial legacy of apartheid, and its resultant poverty, there is energy poverty and

[24] Minister of Mineral Resources v Stern and Others; Treasure the Karoo Action Group and Another v Department of Mineral Resources and Others (1369/2017; 790/2018) [2019] ZASCA 99; [2019] 3 All SA 684 (SCA) (4 July 2019); Sustaining the Wild Coast NPC and Others v Minister of Mineral Resources and Energy and Others (3491/2021) [2022] ZAECMKHC 55; 2022 (6) SA 589 (ECMk) (1 September 2022).

infrastructural deficit in former homelands and urban townships (Noble and Wright, 2013). And because the coal mining industry is concentrated in the north-eastern part of the country, the impacts of transition will be felt most acutely in these states (NBI – Renewables, 2022).

2.5.3. Restorative justice:

Restorative justice has gained momentum in the just transition debate in recent years, developing from its origins in criminal law to become a central part of many energy transition decision-making processes (Lacey-Barnacle et al., 2020; McCauley and Heffron, 2017; 2020; Siciliano et al., 2018). It is a founding principle in the PCC framework, and essentially acts as a means of redress for past harms, and an *ex-ante* methodology to prevent future damage, notably by the mandating of social and environmental impact assessments prior to any development (Lacey-Barnacle et al., 2020; Siciliano et al., 2018).

Although the PCC highlights the need to “heal […] the land” (PCC - Just Transition Framework, 2022 p. 9), it is explicit in its interpretation of restorative justice, which is to give priority to damaged or disenfranchised communities, though what this means in material terms for South Africa is not yet clear. The PCC outline several pre-existing policies, though to date these have had mixed results. Examples of this are that insufficient efforts were made by central government at environmental remediation following acid mine drainage (Minnaar, 2020); and the (still beleaguered) land reform policy. The PCC are also explicit on the need to include broad-based Black Economic Empowerment (B-BBEE) policy as part of the energy transition, a policy designed to “advance economic transformation and enhance the economic participation of black people in the South African economy” (DTIC, 2023), as well as to facilitate community ownership of new resources. This question of ownership is prominent in South Africa’s energy transition landscape, for it is a source of conflict among stakeholders, particularly between organised labour and the private sector: as, for example, when Numsa attempted to block Eskom from signing contracts with private renewable energy companies in 2018 (Connolly, 2022). It is also open to the criticism that ownership rules are being exploited by entrenched elites in the coal sector to promote their own interests, and in doing so to perpetuate the Minerals Energy Complex (Lawrence, 2020 ; Hanto et al., 2022).

2.6. Resource-making and geo-imaginaries, speculation, and the politics of possibility

2.6.1. Critical resource geographies and the subsurface

The subsurface is a sphere rich in resources, including water, precious metals and other minerals, as well as the means of energy production, such as oil and gas and geothermal energy. It provides additional *space* in cities and is increasingly being seen as a site for storage for anything from household waste and radioactive materials to excess CO_2. It is also a sphere full of controversy, from land ownership disputes and water-use rights to the extraction and burning of fossil fuels. It is for these reasons that the subsurface can be seen as more than just a sum of its biophysical properties, but rather a system that is inherently connected to politics, policy, the economy, and technology (Kinchy et al., 2018). It is also a dynamic system, not only because of shifting tectonics or constantly flowing groundwater, but because the social factors that determine the use and value (both economic and social) of the subsurface are also in flux. Because of this, in order to study the subsurface, and what its *value* to society is, it is necessary to establish how questions involving the subsurface are framed, how the knowledge underpinning decisions is created, how conflict is resolved, how extraction, abstraction, and storage takes place, and how the consequences of these activities are dealt with (Kinchy et al., 2018; Richardson and Weszkalnys, 2014). It is also necessary to examine the role that different actors involved in the study of the subsurface fulfil, whether the public, the policy-maker, the natural scientist, or social scientist, as these all influence the perception of the subsurface and its associated natural and social systems (Kama, 2019; Kinchy et al. 2018).

Critical resource geographies is a developing discipline that seeks to address some of these questions. Briefly, it seeks to provide a critical analysis of resource systems by framing them in their historical and contemporary geographies, thus enabling a greater understanding of contemporary issues that can, at least in part, be attributed to resource extraction, such as coloniality, racial capitalism, and the “resource curse” (Valdivia et al., 2021). As a means of meeting this objective, Valdivia et al. (2021 p. 3) suggests that three questions provide the rhetorical framework of the discipline: 1: How do resources matter to the material organisation of human societies? 2: How do resources become meaningfully present in the world and what makes this possible? 3: What would another world of, or without, resources look like? These are framings and questions that resonate with this research, and one particular facet of the critical resource geographies thesis that is significant in this research is that of resource-making.

2.6.2. Resource-making

Resource-making describes "the relations and practices through which landscapes and materials are rendered knowable and actionable *qua* resources" (Kuchler and Bridge, 2023 p. 2); which is to say, that for geological *substances* (*e.g.* metals, oil shales, groundwater) to become resources (*i.e.* a known, exploitable, commodity), they must first be subject to scrutiny and interrogation (*e.g.* scientific, economic, political, or cultural) (Bridge, 2011; Himley, 2021; Kama, 2020). It is apparent that the practices that engender resource-making, scientific, economic, and political, are often controversial (Kama, 2020), raising questions such as: by whom are these evaluations being made? What criteria are they being judged on? And to what ends? (Valdivia et al., 2021). Given shale gas' status as an "unconventional" resource,[25] these questions are particularly relevant.

By situating these types of question in resource geographies, it becomes possible to address them using a number of methodological approaches, and to incorporate a number of relevant fields of study *e.g.* political geography, politics of governance, economic geography, history of science, STS (Himley, 2022; Kuchler, 2017; Kuchler and Bridge, 2023), into the process. This approach lends itself well to the study of unconventional resources, and their wide-ranging externalities. Given the somewhat political nature of this research, it is proposed that this approach will facilitate a critical appraisal of both the broader geopolitical aspects of the shale gas resource debate, and of micro-political analyses exploring *governmentality* (Kuchler, 2017; Lövbrand & Stripple, 2015).

In addressing the *who, what, and why* outlined above, it is proposed that the STS framework identified in section 2.3 provides a useful starting point to address the "why," but "what" and "why" questions require further exploration. When viewed through a critical resource geography lens, unproven shale gas can be seen as an "unsettled and provisional" resource , that is, their as-yet undetermined value makes them a resource "that are in the process of becoming but have yet to be" (Kuchler and Bridge, 2023 p. 2). How then, does a provisional resource become realised? Perhaps, as has been suggested, they become embedded in geo-imaginary, and socio-technical imaginary, horizons (Jasanoff and Kim, 2013; Kuchler and Bridge, 2018; Kuchler and Bridge, 2023).

2.6.3. Imaginaries and knowledge

Kuchler and Bridge (2018 p. 137), describe "imaginary", in a social science context, as "shared conceptions of the world and the social meanings that attach to it", and "the cultural and political work of these meanings, and how "the capacity to imagine futures is a crucial

[25] Kama (2020) provides a useful interrogation of the application of "unconventional" in a resource-making context.

constitutive element in social and political life" (Jasanoff and Kim, 2009 p. 122; Kuchler and Bridge, 2023 p. 137). So geo-imaginaries are the process by which provisional resources are attached to broader socio-economic, or socio-political goals. What these goals are, and how the imaginary horizons are framed, is inevitably dependent on local realities. However, shale gas has been projected, at different times and in different regions, as a means of improving energy security, reducing dependence on foreign energy supply, and as a means of achieving socio-economic objectives (Kama and Kuchler, 2020). Further, Janzwood and Millar (2022 p. 8) describe gas as "malleable", in that its framing in imaginary horizons is simultaneously positive and negative (*e.g.* clean or polluting fuel), depending on who by or where the imaginaries are framed, which is relevant to the discourse analyses elements of this research.

Alongside geo-imaginaries, there is also a developing concept of sociotechnical imaginaries, and how these influence the reconfiguring of national and international energy systems (Jasanoff and Kim, 2009, 2013, 2022; Kuchler, 2017; Wentland, 2016), and how local historic and existing energy systems influence the framing of systems change, which when situated in South Africa, and in the ongoing legacy of apartheid on the national energy system (Baker and Phillips, 2018; Baker et al., 2014), presents a useful critical framework. This literature offers a complementary critique to the energy transition discussion outlined above, and also to related concepts such as technoscientific promises, originating from the Sociology of Knowledge Approach to Discourse (SKAD) (Cantoni et al. 2018; Keller, 2011).

Kama and Kuchler (2019) have examined the way in which the geoscientific knowledge underpinning much of the UOG policy in Europe was generated, and how essentially speculative figures came to dominate the UOG discourse. They claim that certain stakeholders involved in the UOG industry have been acting as resource-makers (see also Bridge, 2010; Kama, 2019; Richardson and Weszkalnys, 2014), by transforming geological survey estimates into measurements, so creating forecasts that are highly speculative and based on limited data from either exploratory drilling or geological research. They further argue that these speculations very quickly cemented themselves within the UOG discourse, to become "*performative*" and to influence policy and investment strategies, thus creating an "economy of expectation" (Kama and Kuchler, 2019; Weszkalnys, 2011). This can manifest in a number of ways. Kuchler and Bridge (2023) identify "spill-over[s]", in which speculation crosses over from the epistemic to the market and political realms, instigating market activity, such as the trading of drilling concessions (Kuchler and Bridge, 2023), and political / sectoral activity, such as infrastructural development "as gestures [to] suggest the existence of productive potential" (Weszkalnys, 2017 p. 2).

Resources, it seems, are not a *fixed* entity, but are changeable according to factors such as technological advances, operating costs, industry scale, scarcity, and fuel prices (Andrews, 2013; Kama and Kuchler, 2019). All this suggests that gas is not just a physical and quantifiable resource, but also a social construct, and that its *value* is determined by a combination of these factors (Kama and Kuchler, 2019; Kinchy et al., 2018): a conclusion relevant to the questions addressed in this research.

2.7. Summary

In this chapter I have outlined the key literature that has influenced this thesis, and the specific contribution this literature may have had on the research papers. The chapter has covered the broad conceptual areas of science and technology studies, energy transitions, resource geographies, and common-pool resource literature, because these have provided the overarching framework of this research. That this is such a broad conceptual umbrella is a reflection of the challenges in researching the development and governance of natural resources, and the different and distinct elements of this chapter directly contributed to each of the papers. Energy transitions are the primary focus of Paper 1; resource geographies of Paper 2; and common-pool resource literature of Paper 3, though there was a considerable cross-fertilisation of ideas between the papers and their primary conceptual underpinnings. The key themes of part 2 in this chapter, and their grounding in wider common-pool resource literature, have provided a structural framework for much of this thesis. The STS *core set*, and key theme 1 influenced the methodological approach for Papers 2 and 3, and their focus on the Presidential Climate Committee, and on gatekeepers of scientific knowledge respectively. The resource geographies literature was a basic influence on both Papers 1 and 2, and the rest of the thesis follows a loose structural narrative influenced by the key themes, combined with other concepts introduced in this chapter.

3. Methods

This thesis uses a mixed-methods approach. Primary data is principally drawn from semi-structured interviews conducted both on-line and in-person throughout the course of the PhD. The research also makes extensive use of secondary data through the form of document analysis. Fieldwork, including observation, and/or participation in a variety of events, outlined in part 2, also constituted a significant part of the data collection process. Inferences and conclusions derived from these practices are not always used as primary data, but they nonetheless provided invaluable experience that helped to shape the trajectory of the research. The methodological approaches of the individual papers are outlined within each one, but the present chapter provides a more detailed and inclusive account of the methods and their application. This additional information includes details that were necessarily omitted from the papers prepared for publication, including contextual information, the processes involved in the choice of methods, their development, and an objective analysis of their relative strengths.

This chapter is in two parts. The first addresses the development and application of the methods used for the three papers prepared for publication, providing the data outlined above. This includes the preliminary research approaches, a detailed description of the interview and data analysis processes that influenced the research. Within this account is a discussion of the theoretical frameworks of the methodological bases of underpinning the methods used in each paper prepared for publication. The second section is a discursive account of the research process, outlining steps required to create a systematic and robust account of a complex and fluid (overseas) topic. The research process itself informs the outcomes, and for this reason I believed it necessary to provide a narrative record of this process, identifying the steps, and outlining the successes, failures, and dead-ends encountered. Finally, this chapter outlines the decision-making processes, a detailed account of the overseas fieldwork, and the various events and meetings that shaped the research development

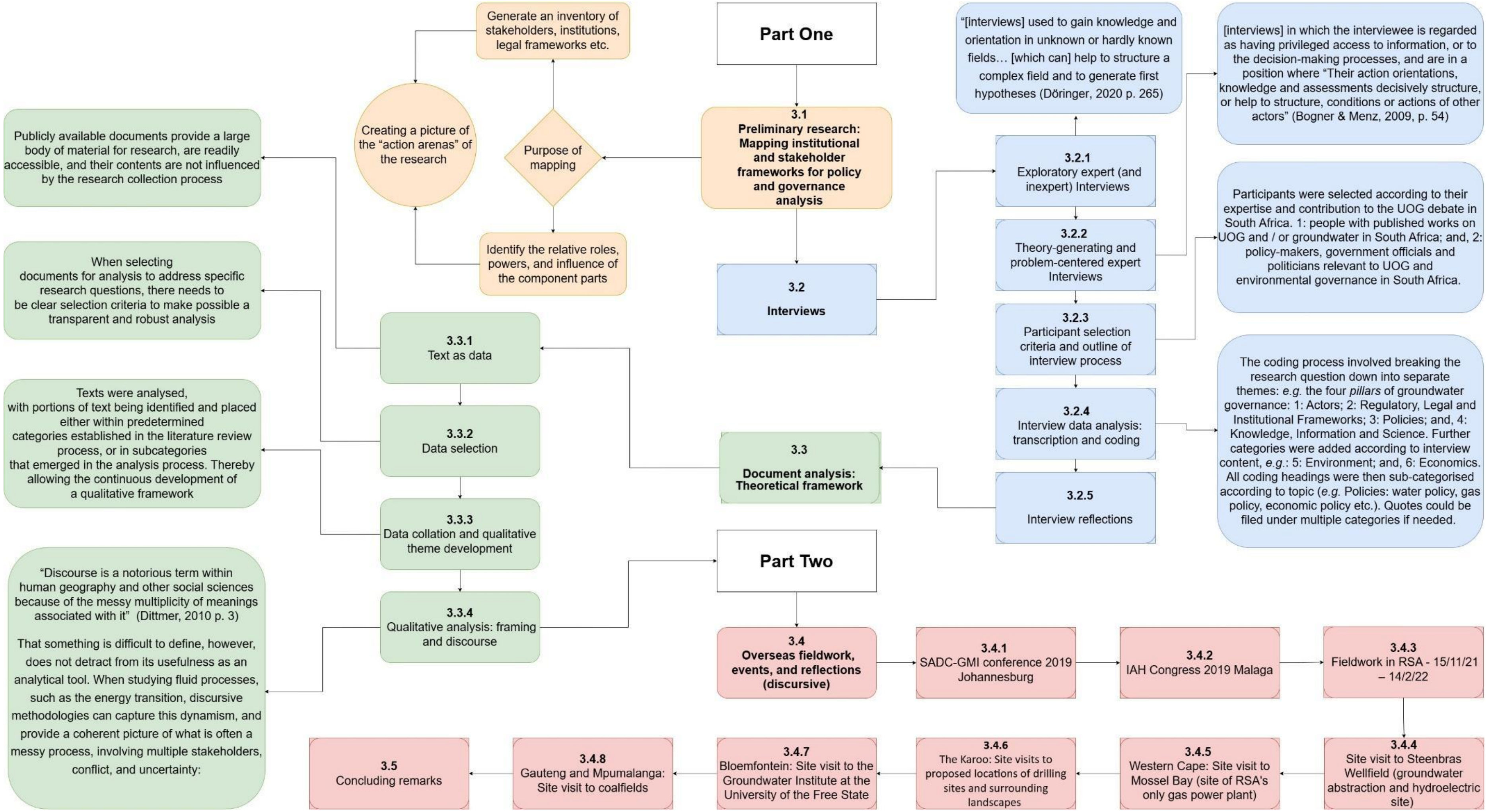

Figure 3.1: Methods Graphical Abstract.

Part 1: Research methods

3.1. Preliminary research: mapping institutional and stakeholder frameworks for policy and governance analysis

The preliminary research questions outlined in section 1.2 were comprised of broad and wide-reaching concepts, (*e.g.* energy transitions, geoscientific *knowledge*, groundwater governance), which are not only broad conceptually, but also in the practical sense. By this, I mean that the institutions and stakeholders involved in these processes are myriad, and are relevant to a variety of systems (*e.g.* energy, water, land). Moreover, these institutions, stakeholders and systems are all to some extent interconnected (*e.g.* the water-energy nexus, socio-economic and socio-ecological components of energy transitions), which made it necessary to map these components. The purpose of this mapping was two-fold: first, to generate an inventory of stakeholders, institutions, legal frameworks etc. for purely practical purposes; and, secondly, to identify the relative roles, powers, and influence of the component parts, which together creates a picture of the "action arenas" of the research (Aligica, 2006. p 80). Owing to this combined function of institutional and stakeholder mapping, it is argued that mapping is two-dimensional, with the first static, and the second dynamic (Aligica, 2006), and that because of this, the process is more than just a preliminary research exercise, but a process that can be revisited and developed throughout the course of research:

> "The applied social science and the public policy literatures abound with references to institutional and stakeholders mapping or analysis. That reflects the importance that this procedure and the problems that it is meant to deal with have in practice. Indeed any social change initiative or any policy project needs for strategic and tactical reasons to get an inventory of institutions involved, identify the key players, assess potential support or opposition among them and to highlight the relevant institutions' roles and the inter institutional linkages" (Aligica, 2006. p 79)

Both of these aspects of institutional and stakeholder mapping proved to be invaluable to this research. First, the static element provided a useful visual asset, and served its practical purpose as an inventory. The value of this was enhanced as it provided a useful way of communicating my preliminary frameworks with stakeholders, and thereby generated discussion regarding the dynamic aspects of the institutional and stakeholder connections, and facilitated feedback from stakeholders, a process that inevitably led to a greater epistemic understanding of the broader institutional setting of the research. Further, it was a particularly useful exercise to maintain throughout the course of the research given that the research was situated outside my country of residence. By generating visual maps of different aspects of the research and communicating these maps to relevant stakeholders, this process created a way of continually *checking* my work with stakeholders in RSA, and a way of identifying knowledge gaps that inevitably exist when conducting research. That much research on institutional and stakeholder mapping was developed to address the questions in the study of common-pool resources (*e.g.* McGinnis, 2000; Ostrom, 1990), resonated with (some) theoretical concepts being addressed in this research. Although the more rigorous theoretical interrogation of the institutions was not the primary purpose of creating these maps (*e.g.* the Institutional Analysis and Development (IAD) framework), in which the institutional arrangements and their development are the research focus, by approaching the mapping process with these frameworks in in mind, and by “analyzing actors, norms, institutional settings, incentive structures, rules, and more” (Indiana University, n.d.), the process was instructive in the design of the research.

Below are two examples of the types of map that were generated as part of Paper 3 of this research. Figure 3.1 provides a graphical representation of relevant stakeholders, figure 3.2 a representation of legislative and policy frameworks. These figures are not intended to be comprehensive, and they simplify complex systems, so are undoubtedly imperfect, but they nevertheless provide indications of, for example, the hierarchical structure of national policies, and the inter-sectoral responsibilities of institutions. This process ultimately contributed to the key point of the research process, ensuring the *right* questions are asked to the *right* people

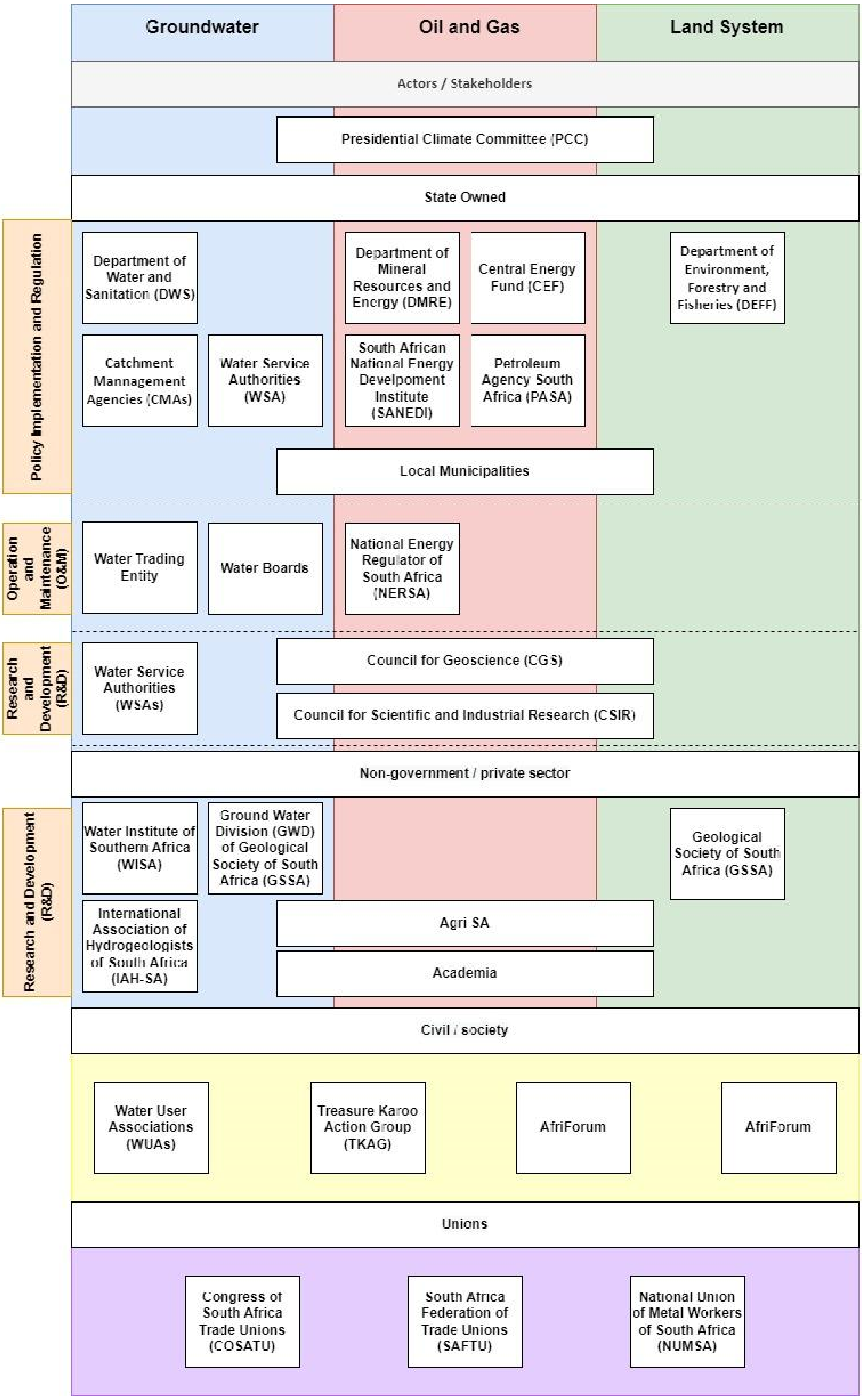

Figure 3.2: Graphical Representation of Actors

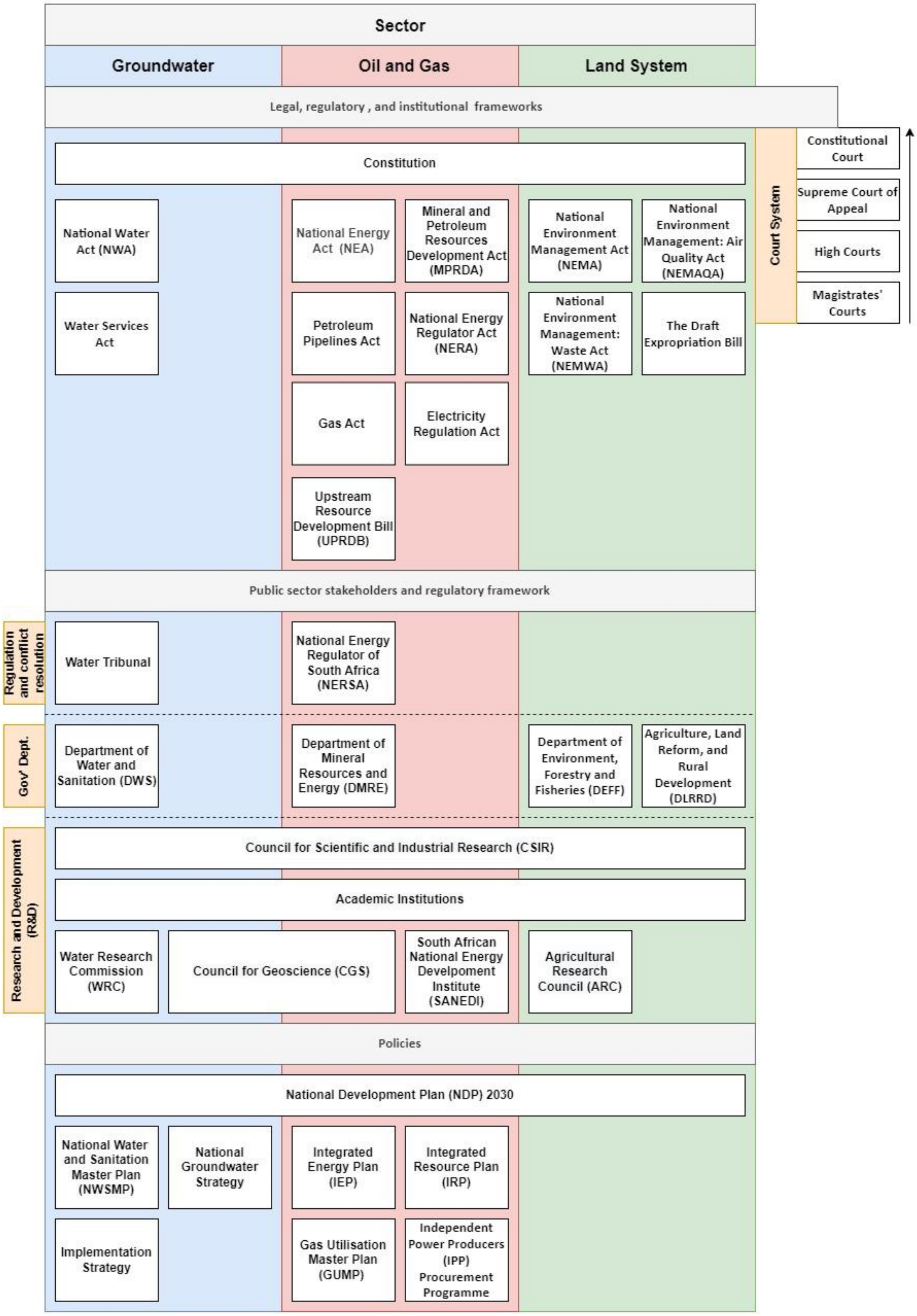

Figure 3.3: Graphical Representation of Legislative and Policy Frameworks

3.2. Interviews

3.2.1. Exploratory expert (and inexpert) interviews

It was clear early in the research project that qualitative interviews were going to be a significant aspect of this research, both as a primary data source, and as a broader method of developing an understanding of the research subject. Preliminary findings from the literature review identified a number of obvious lines of enquiry for potential research participants, particularly the stakeholders involved in the publication of the CSIR Strategic Environmental Assessment for Shale Gas Development in the Central Karoo (Scholes et al., 2016), which is the most comprehensive assessment of shale gas development in RSA so far published. That the publication was divided into subject matter (*e.g.* Effects on National Energy Planning and Energy Security; Water Resources, both on the Surface and Underground), and each section had multiple (expert) authors, provided an opportunity to begin the interview process with a broad-scope, and to begin to establish a rounded overview of the positions held by a variety of stakeholders. To this end, I began the process of conducting a series of "exploratory expert interviews," that is:

"[interviews] used to gain knowledge and orientation in unknown or hardly known fields… [which can] help to structure a complex field and to generate first hypotheses. In this context, interviewees can either be part of the field of interest or serve as an external source of knowledge by providing contextual knowledge about the target group" (Döringer, 2020 p. 265)

These interviews were exploratory, but there was nonetheless a systematic approach to the selection criteria of participants, and one which was initially designed to be wide-reaching. To this end, authors from all relevant chapters of CSIR report were approached, as were other stakeholders that had been identified in the literature review, that is, stakeholders with published works relevant to the research project, or stakeholders that had otherwise been identified as of note, for example, those active in the civic sphere. Further, although the interview design of these exploratory interviews was *less* structured than the more question-specific interviews conducted later in the research (see section 3.2.2), the interviews could still be categorised as semi-structured. Research questions were sent to interviewees prior to the interview (see table 3.1), and I made every effort to familiarise myself with the interviewees' work, particularly relating to shale gas development, in order to encourage dialogue. Given the diverse specialisms of the initial participants, there was a significant knowledge disparity in certain interviews (a challenge cited as problematic in expert interview methodologies (Dorussen et al. (2005)), but given, also, the preliminary nature of this part of the research, this was not deemed particularly problematic. That is, the responses provided by these interviewees were taken on face-value, without the specific design to corroborate their responses, or fact-check their answers (unless they were later included as *facts* rather than opinions in the research findings (see section 3.2.2 for the discussion on respondent reliability and validity).

A critique of the entire interview process is provided later (section 3.2.5), but, briefly, the exploratory interview process consisted of eight semi-structured interviews (see table 3.1) with the object of providing background information for the research topic, and of gaining insight into the positions of a variety of stakeholders. The positive response rate from participants was strong, with several lead authors from the project agreeing to interviews, including, significantly, the project lead. Early input from academic researchers was also good. There was, however, an under-representation from governmental representatives (a persistent challenge throughout the course of the research (see section 3.2.5). All interviews were conducted online, and were primarily (with one exception) with people working in South Africa. The interviews lasted between 30 minutes and two hours, and were recorded where possible. All data was transcribed, and with the exception of one participant, all data was permitted for use in this research.

This process of exploratory expert interviews was instructive. It produced significant material for the further development of the research project, it facilitated the further methodological development of the research, and the refinement of the research questions. Further, the initial relationships developed during this process proved to be instrumental in the later stages of the research. Interviewees were usually asked for recommendations regarding potential participants (snowballing), which led to the successful recruitment of further participants. Finally, where appropriate, participants were asked for both / either follow-up interviews, in which to address more specific aspects of this research (problem-centred expert interviews), or to engage in ongoing correspondence. The purpose of the former is self-evident, and the latter was to reflect the dynamic nature of the research topic, facilitating a scenario in which *live* expert feedback could be integrated into the research in line with any significant developments (specific examples include policy announcements, changes of personnel in significant institutions and the release of new draft legislation).

3.2.2. Theory-generating and problem-centred expert interviews

Interviews played a significant role in all three papers that comprise the main body of this research. Although interview data was the principle primary data only for Paper 3, interviews played a significant role in Papers 1 and 2, with the discussions of both papers drawing to some extent on the findings from interviews. Following the exploratory interview phase, this research used interviews (and their related correspondence) as an ongoing data source, the process continuing alongside other aspects of the research, such as data analysis or preparing papers for publication, and was not considered *complete* until very late in the process owing to the dynamic nature of the project. Because of the dynamic nature of the interview process, it was not always possible to fit them into the preliminary categories outlined in the methodology.

The practical consequences of the interview element of this research, which itself is a reflection of the broad nature of the subject, and of the expertise required for the understanding of the complex socio-ecological/economic/political/technical regimes involved in the novel development of shale gas, and of the research questions outlined in section 1.2, is that the interviews (or series of interviews and corresponding correspondence), often fell into several categories. The interviews were nevertheless designed with specific (if not uniform) objectives in mind, which can be broadly categorised as exploratory, theory-generating, and problem-centred.

Theory-generating expert interviews are those in which the interviewee is regarded as having privileged access to information, or to the decision-making processes, and are in a position where:

> "Their action orientations, knowledge and assessments decisively structure, or help to structure, conditions or actions of other actors" (Bogner & Menz, 2009, p. 54)

Given the privileged knowledge held by the participant, the purpose of interviews of this nature is to extract this knowledge, which is necessarily interpretive, to provide insight into otherwise inaccessible information. This type of data collection has both advantages and disadvantages. On the one hand, having access to otherwise inaccessible information provides opportunities for meaningful and novel research, and by being provided with an interpretive appraisal of this privileged information affords a unique insight into opinions of stakeholders who are in possession of the knowledge (Döringer, 2020). Conversely, however, data collection that relies on privileged information can be less easily deconstructed, since the reliability of the data is necessarily a product of the of the expertise of the interview subject, and verifying this data can be problematic (Beyers et al., 2014; Döringer, 2020). Further the asymmetrical positionality of interviews of this nature can lead to poor data collection. The interviewee's perception of the interviewer can influence responses, particularly if the interviewee can be perceived to be a potential critic, or if the objectivity of the interview and research objectives are suspect, or if the interviewer is perceived to be inexpert (Döringer, 2020).

This research necessarily to drew on theory-generating expert interviews. Even the limited access that was granted by government employees (*e.g.* participant 4), or participants with direct access to government employees (participant 9) (see table 3.1), generated information on the governments' mechanisms of policy development that would otherwise have been missing. For example, one interview discussed the influence of different sectors on government policy:

> "We just recently, 2 weeks ago, came from a meeting with the minister for the DWS […] In economic terms, agriculture is a very small player, as far as primary production is concerned, but it certainly punches well above its weight as far as policies and engagement with government and public profile is concerned" (participant 9)

This sort of information provides valuable context and insights into the ministerial decision-making processes, and when applying qualitative analysis to data is particularly useful. Power dynamics such as these, and the capacity of institutions to influence outcomes are discussed extensively in common literature (see *e.g.* Ostrom, 2006; Ostrom et al., 1994), so, information such as this becomes formative in the qualitative analyses. However, this information is also interpretive, so care had to be taken when applying this type of information to not inadvertently introduce participant bias and error into the qualitative appraisal. For example, in this instance, that the participant was a senior policy-maker and lawyer for an agricultural lobby group, leaves open the possibility that their interpretation of sectoral influence is overstated. But as long as the interpretive aspect of response is considered, the contextual value of such discussions is nevertheless high.

Problem-centred expert interviews involve a less asymmetric approach to knowledge-generation, in which the interviewee and interviewee combine knowledge through an iterative, dialogue-based approach (Döringer, 2020). To this end interviews of this nature rely more on open-ended questions, and progress (loosely) from a narrative phase, in which the participant is encouraged to discuss the broader research topic, to a general and specific exploration phase, in which the interviewer directs the participant to areas of specific interest within the research (Döringer, 2020; Witzel and Reiter, 2012). Interviews following this structure facilitate a more investigative interrogation of expert knowledge, assuming the participant is open to such dialogue, and can provide new insight based on the collaborative knowledge of the researcher and the interviewee (Döringer, 2020; Witzel and Reiter, 2012). An example of this approach was a discussion in which methods of attracting research participants from hard-to-access sectors was addressed, and the interviewee considered the methodological approach of the research, creating a situation in which the participant is simultaneously providing knowledge, and participating in the development of the research itself.

> *Interviewee*: Back to your methodology, […] have you managed to speak to any gas companies or oil companies?
>
> *Interviewer*: no, I haven't, I'm looking for some advice on a tactical approach
>
> *Interviewee*: I had some pro-fracking people, and I asked them [in survey] what's your occupation, [...] they identified as being geologists and I think one of them worked for a petroleum company. […] there are people that work for the exploration companies and geologists. Starting with CSIR would probably be your way in (participant 7)

Problems arising from employing an open-ended approach to interviews include its potential to digress significantly from the areas of interest. Although a broad perspective provided by the participant can be useful, and generate valuable contextual information, time restraints, both of the researcher and participant, mean extended discussions that lack specific focus can prove less instructive than a more direct interview technique (Döringer, 2020; Witzel and Reiter, 2012).

Finally, the value of follow-up interviews and ongoing correspondence with participants cannot be understated in the research process. The relationships established throughout the interview process meant the dynamic nature of the research topic could be reflected in the data.

3.2.3. Participant selection criteria and outline of interview process

Participants were selected according to their expertise and contribution to the UOG debate in South Africa. The participants selected fell broadly into two categories: 1: people with published works on UOG and / or groundwater in South Africa; and, 2: policy-makers, government officials and politicians relevant to UOG and environmental governance in South Africa. Participants from category 1 were identified throughout the literature review process (see chapter 2) and participants from category 2 were identified by both the literature review process, and through regular internet searches of media and technical reports, and political documents. All participants were contacted through their organisation email address, and all emails were individually tailored to include a description of the reason for my interest in the particular participant (usually a recent article). Emails followed a generic formula, including background to the project and reason for the interviews (see appendix iv), and also had attached the Lancaster University FST department approved participant information sheet (PIS) and consent form (see appendix v). Once participation was agreed, a brief outline of questions was created and sent to the participant in advance of the interview. Interviews were conducted both on-line or in-person, depending on location and COVID-19 restrictions and advice in place at the time (see section 3.4). All interviews were recorded where this was possible. The interviews that were used as primary data are indicated in table 3.1, alongside further information on all interviews conducted throughout the course of the research.

3.2.4. Interview data analysis: transcription and coding

Transcription process: The transcription process was done in three parts: 1: recordings were played from Voice Recorder to Google Live Transcribe (automatic transcription software); 2: The resulting transcription was transferred to F4Transkript, (manual transcription software), where the original recording speed could be slowed down, allowing me to carry out the necessary transcription corrections that occurred in the Live Transcribe document; 3: the F4Transkript document was exported to Word, where a final edit of spelling and grammar was performed. The final transcript was then copied into F4analyse (coding software) for coding. All transcripts are time stamped after each paragraph, and the transcripts are linked to their respective audio files, so all data can be played from anywhere in the file to confirm accuracy and assist interpretation (*e.g.* emphasis, sarcasm etc.).

Coding methods: Different code headings were applied to each of the three papers, but the system applied was the same in all cases. Coding was used most extensively in Papers 1 and 3. For clarity, the explanation of the coding system will use examples exclusively from Paper 3, which was also the paper that used primary interview data most extensively.

The initial coding process involved breaking the research questions down into separate themes. Using the examples from Paper 3, these initial themes were those identified in the literature review (section 2.2) as the four *pillars* of groundwater governance: 1: Actors; 2: Regulatory, Legal and Institutional Frameworks; 3: Policies; and, 4: Knowledge, Information and Science. These pillars acted as the initial framework for coding. Further categories were added to cover all areas covered throughout the interviews, these were: 5: Environment; and, 6: Economics. All coding headings were then sub-categorised according to topic (*e.g.* Policies: water policy, gas policy, economic policy etc.). Quotes could be filed under multiple categories if needed. See figure 3.2.5 for an example of how the coding system is formatted. Using this technique allowed me to navigate large volumes of transcript data in a systematic manner.

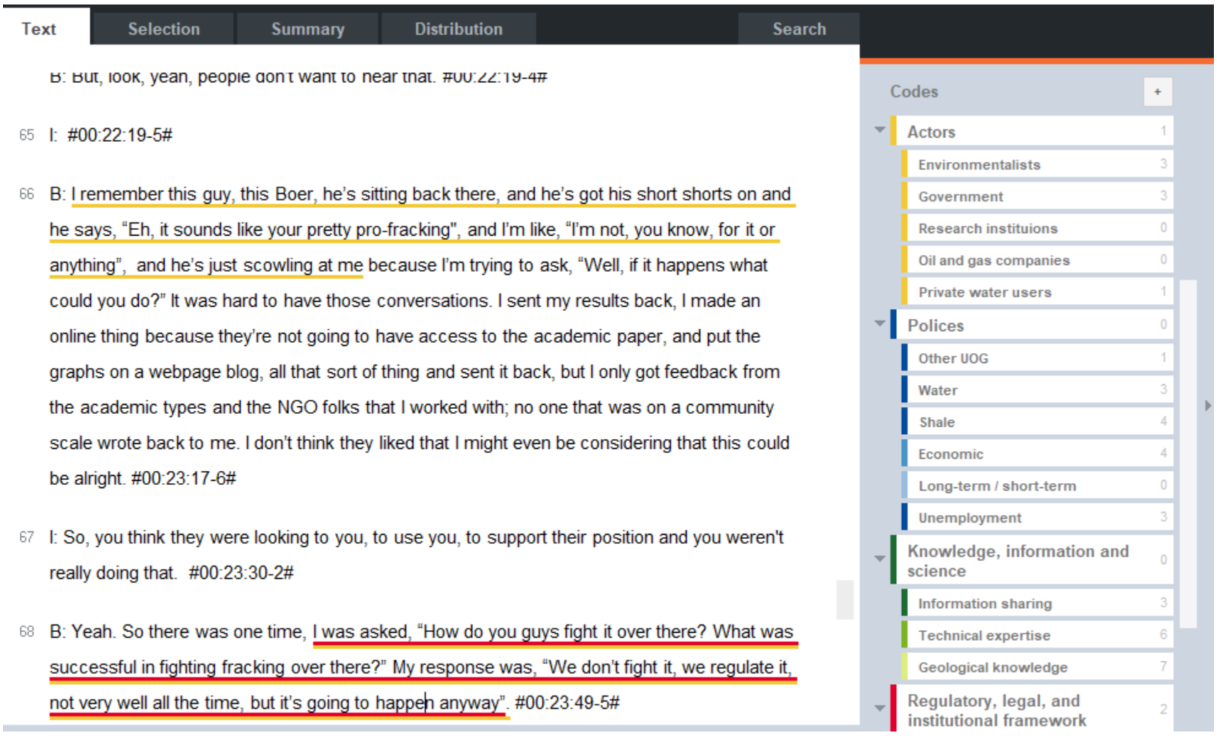

Figure 3.4: Showing an example of the coding system used. See underlining: yellow = Actors, red – Regulatory, Institutional and Legal Frameworks, # = Timestamp. (Text panel removed to protect anonymity).

3.2.5. Interview reflections

This section is a brief reflection on the interview process, included to identify some of the strengths and weaknesses of the overall approach, in order both to critically evaluate my own work, and to share this with the reader.

Participant selection, response rate, and representation: I believe that the initial selection-criteria were sound. The CSIR report and the wider literature review identified the required participant targets, and during the ongoing processes of literature reviews and interviews, knowledge gaps could be addressed throughout the course of the research. The positive response rate was generally good, particularly from authors involved in the CSIR project and from people involved in relevant academic research. The interview response rate was, I believe, markedly improved by the early involvement of some influential figures in RSA shale resources development. These included the late Professor Bob Scholes (anonymity explicitly waived), who was project lead on the CSIR assessment, who not only offered invaluable insight into the research questions and research development, but also provided names and contact details of numerous potential participants, made introductory emails on my behalf, and gave explicit permission for me to use his name in my requests for participation. This made a huge difference to the research, especially in the exploratory interview phase, as these contacts might not have participated without this early endorsement. Additionally, participants 1, 2 and 4 also provided introductory emails on my behalf, again, providing opportunities to pursue research avenues that might not otherwise have been available.

The interviews themselves were mostly successful. I managed to establish a good rapport with all participants except one (participant 6, see below), and generally achieved what I intended to in each interview. The preparatory work particular to each participant, although time-consuming, was worthwhile, as it facilitated much richer discussions than might otherwise have been possible, particularly with participants whose expertise was far removed from my own. Providing participants with questions beforehand also worked well, as in some instances, it was apparent that the participants had also spent time preparing for the interviews. This preparation allowed participants to have information to hand, and also to provide supplementary material beneficial to the research. The duration of the interviews, mostly half an hour to an hour (I tried to book one-hour time-slots with participants), proved to be a solid format, though I made sure I had extra time available if needed, but with a few exceptions, an hour was adequate.

The obvious shortcoming of the interview process was the lack of involvement of senior policy-makers. Despite my best efforts, and the efforts of other influential people on my behalf (notably F Krige and his former colleagues from the SABC (see section 3.4.8), no politicians or senior policy-makers from identified institutions were willing to take part. This is not particularly surprising, given the nature of the research and the roles and responsibilities of these people, but their participation would undoubtedly have improved the project. However it is difficult to imagine how, given the circumstances, I could have realistically made a material difference to this outcome.

The second shortcoming of the interview process, identified in the peer review of Paper 3, was the lack of representation from the government agencies PASA and CGS. Again, every effort was made to recruit participants from these agencies, but without success. The potentially controversial nature of the research project may have influenced this lack of participation, or alternatively, as one participant pointed out, there may be an institutional reluctance to be involved in projects such as these:

> “You'll struggle to get anybody to give you a straight answer because they don't want to be seen or to be quoted in case they're wrong, it's something we are finding with all sorts of things […] don’t expect a reply any time soon” (participant 11)

However, it is not unreasonable to assume that participants from these agencies may have been willing to participate, but my approach may have been hindered by the limited time spent in RSA (see section 3.4), for if I had been able to establish personal connections, it may have facilitated a more positive response. This problem was amplified by the prohibitively expensive and exclusive nature of many of the events associated with gas development, particularly, although not exclusively, those organised by the private sector.

I further identified a lack of diversity within my research participants as a potential barrier to more broad institutional representation, and a richer discussion more generally. All my participants had either English or Afrikaans as their first / preferred language, and all, with the exception of two participants, were white. This is obviously not representative of South Africa as a whole, and may well not be representative of the institutions of the participants, though I do not think that unconscious bias (as a white male), was a factor, particularly in the initial stages of the research when I was communicating via email to attract participants (though admittedly peoples' names in South Africa often give some indication of their heritage). But, given the numerous conferences I attended in Southern Africa, unconscious bias may have influenced my interpersonal reactions, because race is obviously a complex issue, not least in South Africa, and greater diversity in this research project would have been welcome. Again, more time in South Africa would have improved this, but as identified in section 3.4, travel restrictions limited that opportunity.

Logistical issues were sometimes a problem with the on-line interview process. Several participants were working from home (COVID-19), and internet connection was at times unreliable for some of them, as was the (then) limited platforms for online conferences (Skype, Teams, and Zoom were all used). Although this inevitably created a barrier, it did not actually prevent any planned interviews, although it did make some interviews somewhat disjointed (participant 6 involved four telephone calls owing to connection disruption).

Broadly speaking, the interview process presented very few ethical questions that needed careful consideration. The primary concern, which I related clearly to all participants, was that although all contributions were anonymous, the reality was, that given the relatively small research community which the research drew on, it would not be inconceivable that people familiar with the subject would be able to identify participants from the generic descriptions and response in-text. In fact, no participants raised any concern about anonymity. There were rare instances where information was provided off the record, requests that were of course respected, and because all the interviews were with experts, there were no issues regarding positionality to influence the research findings.

Finally, it is my belief that the controversial nature of shale gas development in RSA had conflicting influences on the research project. As mentioned, I think it may have prevented certain institutional involvement, and conversely, certain participants were particularly keen to get their voices heard, explicitly waiving anonymity. One participant specifically requested that

I not use their interview in the research, as they believed what I categorised as academic neutrality amounted to the promotion of fossil fuel development. These facts, and their potential to inadvertently skew the qualitative aspects of the research, were allowed for throughout the research process.

3.3. Document analysis: theoretical framework

Document analysis was the main basis of Papers 1 and 2 of this thesis, so the following section discusses the conceptual framework underpinning this qualitative analysis. It explains, and discusses, how documents were selected, and what interrogation the documents were subject to, in order to carry out a robust qualitative analysis. The data analysis aspects of both Papers 1 and 2 are dealt with at the same time, and will include a critical appraisal of the process.

3.3.1. Text as data

Document analysis is the obvious point of entry for any research addressing topics such as the framing of gas in energy discourse (Paper 1), and of resource-making and geo-imaginaries in the energy dialogue (Paper 2). Publicly available documents provide a large body of material for research, are readily accessible, and their contents are not influenced by the research collection process, as could be the case with, for example, interviews, or observation. Documents are simply resources waiting to be found and analysed (Karppinen and Moe, 2012), but, the selection of data, its availability and reliability, and the collation and analysis of selected documents, involve methodological problems that need to be addressed (Karppinen and Moe, 2019).

3.3.2. Data selection

When selecting documents for analysis to address specific research questions, there needs to be clear selection criteria to achieve a transparent and robust analysis. In this research, the concept of "energy discourse", for example, is open to a number of interpretations, so the focus needs to be both broad enough to capture the diversity of the research subject, and sufficiently limited to enable reasonable conclusions to be reached. Moreover, the documents have to be selected in a way that limits the potential for bias (or "cherry-picking" (Ahuvai, 2001 p. 146)). To this end, the document selection criteria of both Papers 1 and 2 were designed around specific, although very different, frameworks.

In Paper 1, using the Presidential Climate Commission (PCC) as the focus of the energy discourse provided a robust framework for a document analysis. The PCC was established to provide a platform for discussion by a broad coalition of stakeholders, so by limiting the research to documents produced by the PCC's commissioners, a focussed, yet suitably broad, selection criteria was possible, though limiting the scope of the document analysis excluded those not included in the selection framework. In practice, within the PCC the only notable exclusion was representatives of the Democratic Alliance (DA), the second largest political party (the DA are now represented in the PCC, but were not at the time the analysis was conducted). Once the PCC had been established as the framework for the document analysis, the selection process became straightforward, with well-established parameters to maintain clarity:

> "Publicly-accessible documents that were either published by commissioners or on their behalf, published by the groups the commissioners represent, or statements made publicly by commissioners to media outlets in a personal capacity" (Paper 1)

Paper 2 applied two separate frameworks for selecting documents. The first used documents that included explicit numerical shale resource estimates; and the second (only applicable to the gatekeepers) was a broader category that captured documents discussing shale resources. This first stage of the document analysis was clearly delineated, and resulted in a broad preliminary data pool; however, the specific document selection process turned out to be more challenging. Numerical resource estimates are widely used, so to narrow the selection criteria to a manageable dataset, yet still capture the "national dialogue", required further consideration. The first problem was deciding what type of document was to be included in the selection process. It was decided early on to exclude private company reports, as these can reasonably be categorised as outside the national dialogue. The field of research was therefore narrowed to that of the media, but this also presented a number of methodological challenges. Firstly, what forms of media were to be included in the process? The approach adopted was to only use documents from what would be broadly categorised as mainstream or mass media (*e.g.* newspapers and public broadcasters), and to exclude alternative media sources (*e.g.* social media and blogs). This is not to argue that the excluded media sources do not constitute part of the national dialogue, but rather that their inclusion would be incompatible with a research project of this nature, owing to the sheer volume of data this would have generated, and the corresponding analysis this would entail. The second challenge was to establish a timeframe for analysis. Given that the numerical estimates that formed the focal point of the research were associated with specific dates (the EIA reports – 2011 and 2013, de Kock et al., 2017), and PASA estimates (2019), the years 2011 - 2023 provided the most obvious timeframe for data selection. Preliminary research, however, suggested that the further back into the media archives I looked, the more sporadic the relevant material became, with older archival material clearly having been removed from public access. To get round this, a timeframe of 2016 to the present was decided upon, as this encapsulated de Kock et al. (2017), and the period adjacent to its publication. The exclusion of media data between 2011 and 2016 can be justified by the gatekeeper aspect of the data selection framework, which concentrated on the EIA estimates, and by merging the two data selection frameworks, a robust data selection criteria was achievable. Finding a balance between the quantity of material used, and the quality of the corresponding analysis, was not easy, and there is no single solution, because, for example, pinning down a concept like "national dialogue" is inevitably imprecise. Nevertheless, it seemed that the method applied in practice captured a sufficient dataset to facilitate a convincing qualitative discussion.

3.3.3. Data collation and qualitative theme development

Using a similar technical approach to the one used for the interview transcription data, documents were uploaded to F4 software, and the texts were analysed, with portions of text being identified and placed either within predetermined categories established in the literature review, or in subcategories that emerged in the analysis process. This allowed the continuous development of a qualitative framework, as each document was being evaluated in turn. Using Paper 1 as an example (see figure 3.4), these included categories such as "Gas as transition fuel", with subheadings of "Trade-offs", further subdivided into positive, negative and neutral. This approach facilitated a systematic approach to data storage, retrieval, and interrogation., and it enabled me to search the data according to various criteria. So, for example, I could choose to search documents according to publisher (left), qualitative theme (right), or a combination of the two. This facilitated a continual cross-referencing of data, as the qualitative narrative was being developed, which would ensure accuracy in the writing-up process.

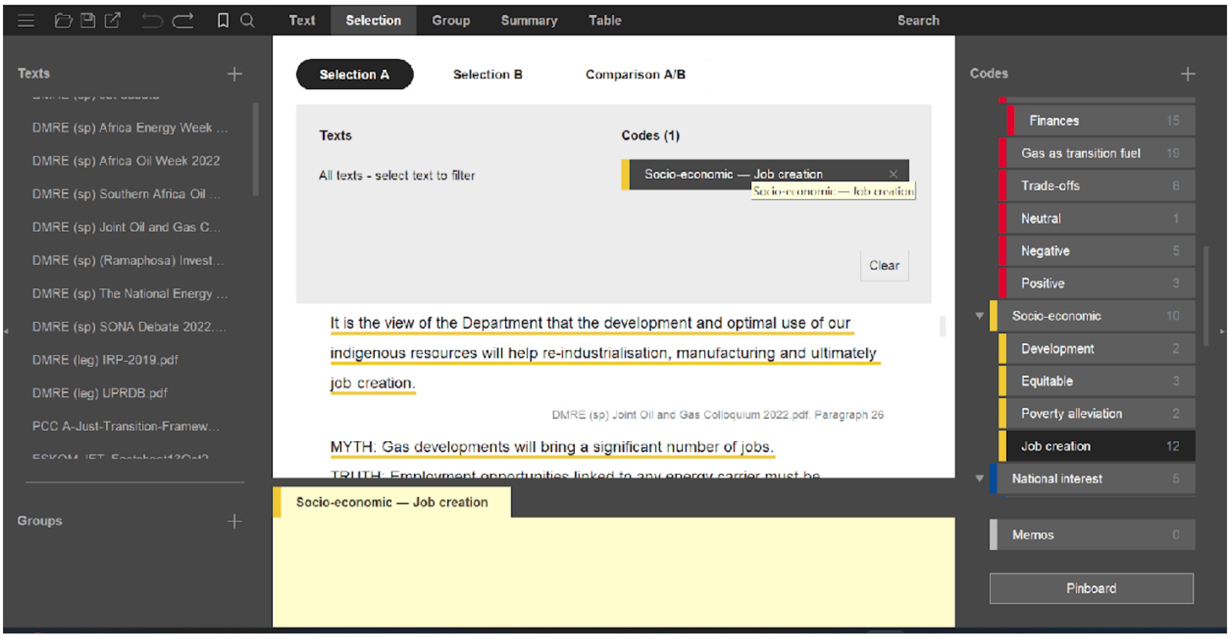

Figure 3.5: An example of the data collation coding system. Left panel shows document publisher, type, and title; right panel shows themed categories headings and subheadings; centre panel shows data selection (e.g. Socio-economic – job creation – all text)

3.3.4. Qualitative analysis: framing and discourse

Papers 1 and 2 both address qualitative concepts that are by nature elusive, difficult to accurately determine, and to define. Both “discourse” (Paper 1), and “dialogue” (Paper 2), have meaning in social science literature that goes beyond their colloquial definitions, as Dittmer (2010) puts it:

> “Discourse is a notorious term within human geography and other social sciences because of the messy multiplicity of meanings associated with it” (Dittmer, 2010 p. 3)

That something is difficult to define, however, does not invalidate its usefulness as an analytical tool. When studying fluid processes, such as the energy transition, discursive methodologies can capture its dynamism, and provide a coherent picture of what is often a messy process, involving multiple stakeholders, conflict, and uncertainty:

> “Discursive approaches are especially apt for the study of socio-technical change in contexts where change is understood as involving power struggles between different actors and coalitions” (Isoaho and Karhunmaa, 2019 p. 940)

These “messy” processes were evident in the PCC stakeholder coalition, in which there was representation from diverse groups, with significant differences not only in their preferred outcomes, but also in their influence. So, the methodological challenge (using the example of Paper 1), was to create an approach through which these aspects of the role of gas in the energy transition could be combined and presented in a way which would allow: 1: the research to reach some reasonable conclusions that contribute the field; and, 2: provide the reader with a coherent overview of the research topic. To this end, the qualitative aspects of the research needed to not only combine the material being analysed, but also to consider issues such as the power and agency of the stakeholders, and their motivations. This approach to discourse, and its subsequent analysis, is described by Dryzek (1997) as:

> "A shared way of apprehending the world. Embedded in language it enables subscribers to interpret bits of information and put them together into coherent stories or accounts. Each discourse rests on assumptions, judgements and contentions that provide the basic terms for analysis, debates, agreements and disagreements" (Dryzek, 1997 p. 8)

Similarly, in Paper 2, in trying to establish the ways in which geo-imaginaries and resource-making (Kuchler and Bridge, 2023) featured in the national dialogue, the challenge was to see how the resource estimates were being *framed*. This idea is cogently described by Entman (1993):

> "To frame is to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described" (Entman, 1993 p. 52)

To research the framing of a topic, in this case, resource estimates, inherently involves the adoption of a subjective and interpretive analytical lens when reviewing documents, but by establishing a coherent theoretical basis from which this subjectivity is based, in this example, that of geo-imaginaries outlined by Kuchler and Bridge (2023), it was possible to create a methodology to critically engage with the use of resource estimates, thereby structuring the method to capture their framing.

It should be noted that in this research, discourse analysis and framing is not intended to be a critical linguistic deconstruction of the research material (see *e.g.* Fairclough and Wodak 1997; Wodak, 2011). The interpretation of Critical Discourse Analysis (CDA) outlined by Fairclough and Wodak (1997) does resonate with this research, particularly in Paper 2, in which geo-imaginaries and their horizons are identified as a source of "social practice". More advanced linguistic analyses, however, are beyond the scope of this research:

> "CDA sees discourse – language use in speech and writing – as a form of 'social practice.' Describing discourse as social practice implies a dialectical relationship between a particular discursive event and the situation(s), institution(s) and social

> structure(s), which frame it: The discursive event is shaped by them, but it also shapes them" (Fairclough and Wodak ,1997 p. 258)

Finally, it is worth reflecting on my experience as a researcher in conducting qualitative discourse analysis. Firstly, although there is clearly value in using such analysis to capture complex and dynamic problems such as those outlined in this research, there is no established framework to achieve this. As Dittmer (2010) identifies:

> "There are many fine examples of discourse analysis in the human geography literature, there are very few explicit discussions of how that research was undertaken. This is, in part, because it is not a stable process, done in a laboratory with infinite iterability, but rather it is more artisanal" (Dittmer, 2010)

This, I believe, identifies the real challenge of discourse analysis, because this "artisanal" element is fundamental to the success or failure of this type of research. It is not that discourse analysis is a weak or robust methodology, but rather that its success is dependent on too many factors to identify *a priori*. This problem has been present throughout the course of this research, insofar as it was difficult to see what the outcome would look like until the analysis was complete. My supervisory team repeatedly identified the potential complications that generating and publishing discourse analysis like this would face, and in this they were absolutely correct. However, it remains the case that in this instance (that is the energy policy crossroads in RSA) there seems no alternative to using this sort of data analysis to capture this dynamic process in real time.

Part 2:

3.4. Overseas fieldwork, events, and reflections (discursive)

This research involved both fieldwork and aspects of stakeholder engagement in order to collect primary data (interviews and events). This data was to be the means of acquiring a greater understanding of the research location, of the people involved, and of the broader socio-political, socio-ecological, and socio-technical realities in South Africa. With the exception of the interview data, the fieldwork aspect did not feature as prominently as initially anticipated. This was for a number of reasons, but primarily owing to the necessarily truncated timeframe for overseas fieldwork owing to COVID-19 (see section 1.6) and the associated uncertainty and disjointed data collection processes. However, the fieldwork that did get done despite everything proved valuable, and I believe has improved the quality of the research well beyond what would have been possible without it.

The following account is broadly chronological, with a few identified exceptions.

3.4.1. SADC-GMI conference 2019 Johannesburg

The Southern African Development Community – Groundwater Management Institute (SADC-GMI) held their second groundwater conference in Johannesburg between the 4th and 6th September 2019. I travelled to RSA for two weeks to attend this conference, with the usual aims of listening, learning, and networking, and also as a reconnaissance trip to help outline my fieldwork that was pencilled-in for April 2020. The conference itself was very well-run, with lots of expert speakers representing all of the SADC region, covering a wide range of topics. Its immediate relevance to the research was somewhat tangential, because although there was a number of talks focussing on governance, common-pool resources, and social science, its focus was primarily on pure hydrogeology. Nevertheless, it turned out that the conference was perhaps the most influential single event in the whole research project. I will explain this further.

I arrived at the conference with a poster for display outlining my research project as it was at this stage (see appendix iii). I decided that to increase my engagement with delegates I would make the poster interactive, leaving a blank space on the poster, providing pens and Post-it notes, and asking:

> "What is your opinion on hydraulic fracturing? How do you think it will impact the equitable and sustainable use of groundwater? Please attach your thoughts, concerns, hopes and expectations to the panel below using the pen and paper provided, and if you wish, contact details so I can follow up on your suggestions"

This failed miserably. I got one single response, and that was from a delegate who I had been speaking to for some time beside my poster, and who I think took pity on me. *C'est la vie.*

The first evening, however, proved much more beneficial. In discussing my work with various people, I was introduced to participant 1, who provided primary data, feedback, advice, and corrections throughout the course of the research project. Similarly, I was introduced to participant 3, who will be introduced later in this narrative.

Finally, and I believe most significantly, I was approached on the final day of the conference for an interview. For context, the conference had engaged a private digital marketing company, who were tasked with documenting the conference and providing a live blog of the proceedings. One of the journalists had overheard my accent, and I was asked for comment. My interview was not in the event deemed newsworthy, but, as I would come to experience time-and-again throughout the course of the research, I was introduced to the generous South

African hospitality. Having established I was in South Africa to plan future research, I was invited to dine with the media team in Johannesburg, and introduced to the esteemed journalist, author, and campaigner Foeta Krige, who will feature later in this narrative.

Figure 3.6: SADC-GMI delegates

3.4.2. IAH Congress 2019 Malaga

The 46th International Association of Hydrogeologists (IAH) Congress was held in Malaga, Spain from 23rd to 27th September 2019. Again, the attendance of this conference was part of my exploratory research, although this event was more directly relevant to the research than the SADC GMI conference. The theme of the conference was “Groundwater management and governance – coping with water scarcity” (IAH, 2018). This event was particularly instructive in the development of Paper 3, and provided the opportunity to discuss my research in-person with a number of the authors of literature that featured extensively in chapter 2.

During the conference I lost my wallet, and received a phone call saying it had been found (I had fortunately printed some business cards as a means of encouraging people to participate in the research). In what turned out to be an astonishing stroke of luck, the person that found my wallet was an employee of the South African government, who was presenting at the conference. This chance encounter established the basis of an ongoing correspondence, and led to numerous interviews, privileged access to data, and facilitated a series of introductions that proved valuable to this research.

The point of this anecdote is to identify the value of interpersonal relationships in the doing of social science. This research would have been much less valuable, both to myself as a student and researcher, but also, I believe, to its outcomes. The carbon footprint of this way of doing research is obviously a concern, and possibly it could be done without the air-miles that went into this project, but it is evident to me that if research of this nature is going to be carried out, a social element is probably essential.

3.4.3. Fieldwork in RSA 15/11/21 – 14/2/22

I eventually arrived in RSA in November 2021. By this time, South Africa had removed most of its COVID-19 restrictions. As identified in section 3.2, I had already done a number of interviews, and had been cultivating working relationships to facilitate the data collection process. However, the fieldwork, although ostensibly years in the making, was essentially unplanned. I had several objectives outlined, and a number of people who had agreed to take part in the research, but I was only aware of the actual dates of the trip a little over one week in advance of my flights. This was because a brief window had opened up allowing me to travel, and various red-lists (travel bans) were being established, so I decided to take the opportunity, rather than delay, to make a more concrete itinerary, and risk being unable to travel at a later date. To further complicate matters, I arrived in RSA five weeks before Christmas. These combined factors necessitated a somewhat *ad hoc* approach to the initial work.

3.4.4. Steenbras wellfield

During the exploratory phase of this research, I became interested in Cape Town's water resource challenges. My focus was primarily directed towards the infamous *Day Zero* scenario, in which multiple factors combined to create a near-catastrophic situation in which the city, for all intents and purposes, ran out of water. This,, and the COVID-19 hiatus, inspired me and two of my department colleagues to write a paper on the subject (Gittins et al., 2021) (see Appendix ii), and encouraged me to pursue the topic further. Briefly, the extraordinary situation initiated (or expedited) a series of socio-technical responses, not least the development of the Steenbras wellfield, in which an array of production boreholes was drilled adjacent to the Steenbras dam system, to augment the city's water supply. This project was a major undertaking that involved complex socio-technical governance to navigate the myriad obstacles in the project's establishment. My initial thoughts were to incorporate a case-study of the Steenbras wellfield into the thesis, as an example of the water-energy nexus (the dam system has an hydroelectric component), and an example of successful stakeholder engagement practices in facilitating effective environmental governance. To this end, I began my research.

Having established a working relationship with one of the project's principal designers at the SADC-GMI conference (participant 3), it was arranged that I could gain access to the wellfield site. I was given a tour of the vast (restricted) dam complex, and learned about the complex ecological setting of the site. Following this, I outlined what I believed to be a robust framework for further enquiry. Having discussed this proposal with my supervisory team, however, and evaluated the overall shape of the thesis, it was decided this work, although interesting in itself, was outside the scope of the overall research project, and the gas *thread* that ties it together.

Although this episode had a negligible demonstrable outcome, it was an instructive experience because the knowledge acquired fed into the subsequent research, particularly owing to the extensive geological expertise of my colleague, but also the process itself, which again, despite the resulting dead-end, was useful in contributing to what it is hoped is the coherent narrative of this thesis. It may be able to complete this work at a later date.

Figure 3.7: Collage of Steenbras Wellfield. L to R – Environmental monitoring; Joint venture engineering; Disused campsite on site; Borehole and equipment housing

3.4.5. Western Cape

Other notable events from my time in the Western Cape were in-person interviews (see table 3.1), one of which led to an invitation to the "DWS Stakeholder Engagement on Unconventional Gas - Research, Knowledge and Academic" event (online). This event provided primary data for Paper 3, and also contextual knowledge about some of the governance challenges that shale gas development presents. Delegates at this event expressed concern that although there had been a series of stakeholder engagement meetings, the difficult / time-consuming / sensitive issues that had been previously identified, were routinely being ignored. This was reflected in the comparatively poor turn-out at this event, and the frustration expressed by a number of delegates about the lack of progress on existing issues, which in-turn were preventing progress on subsequent challenges. This, it seems, has been a recurring theme in RSA's shale gas debate. Policies, legislation, and actions are regularly outlined, but their publication, ratification, and implementation are routinely delayed, an example being the Integrated Resource Plan; Upstream Petroleum Resources Development Bill; or PASA annual reports. The following two quotations are from my interviews discussing these issues:

> "The [draft policy documents] have just been rehashed again… and they were saying, "the regulations sound, we've got the capacity to implement it", and everybody's like "not at all." So, there's no engagement" (participant 2)

> “ [government officials ask] “did you do any work on this and this and that you know for Shale gas development?” and I’ll say “yes! we developed this whole fracking map there it is, there’s the link you can access it for free, please use it for your decision-making. we drafted this whole report to say what are the risks and blah blah blah.” And it's like just “thank you” and you don't hear anything again. And then like two, three years later is again, the same question: “Did you do any work on XYZ ?” and I'm like “man, I've sent this to you like five years ago.” Ha-ha, so no, it doesn't get taken up” (participant 2)

My point is to explain how first-hand experience acquired in attending events such as this facilitates a greater understanding of the experience of the participants of the research. This enables an improved contextual analysis of the data, and thereby, improved the research outcomes.

In my final trip to the Western Cape, I visited Mossel Bay to see the impact of the gas infrastructure from RSA’s only gas power plant (which features often in the geo-imaginaries of Paper 2). I tried and failed to secure interviews with people connected to the facility, or to get access to the facility itself, so this endeavour turned out to be of little direct value to the research. Furthermore, attempts to gain insight from local residents were largely met with indifference. It is clear that it would undoubtedly be possible to gain useful insight from indirect sources but that a more structured methodological approach would be required.

3.4.6. The Karoo

Of all the elements of the research project, my failure to get access to the Karoo Deep Drilling Project, or access to any of the senior figures involved with the project, is my greatest disappointment. Despite my best efforts, the opportunity never materialised. Perhaps I am overestimating the importance of the site, which is after all no more than a small drilling project, and given its remote location, the likelihood of any staff other than the drilling teams and security, being on-site, on a day-to-day basis was slim. I think my disappointment largely stems from a combination of it being the symbolic epicentre of my research, and a nostalgic outlook from my experiences working on drilling projects. However, that I was unable to generate any participation from the CGS is a loss to the overall research. I believe strong participation from the CGS could potentially have translated into good primary data for possibly all three papers, and certainly Papers 2 and 3. But, with research of this nature, certain restricted access is probably inevitable.

Nevertheless, I still went to the site. Much as was my experience in Mossel Bay, discussions with local people were not particularly illuminating (a lot of people I spoke to were not even aware of the site's existence). But, from a purely observational perspective, there was much to see. As my research has identified, many of the aspects of shale gas development that attract attention are those that are in some ways only indirectly linked to the drilling itself, or the so called "fractivities" (see Paper 3). Although it is possible to picture the varying impacts a huge and dispersed gas project might have on a small rural area (and one which reflects the RSA economy more widely in its vastly unequal wealth distribution). But seeing it for oneself brings these theoretical abstracts to life. The lack of infrastructure, underfunded public services, widespread lack of access to basic services, were all apparent in and around the sporadic urban settlements. And while there's no agreement about what the money from such a project would do for an area like the Central Karoo, it's obvious that the wider societal impacts would require careful consideration. Although the prospect of creating boom-town conditions certainly appeals to some, something that as an *outsider* I am in no real position to comment on, the potential for damaging socio-economic and socio-ecological practices emerging in a regulatory vacuum is apparent. This is an interview extract on this point:

> "If people of SA would at least take that precautionary principle, if there's a 1 percent chance that this could happen, they should have some robust guidelines for how it's going to go down. Say that companies need to hire so many local people, they need to invest in skills-based training with transferrable mechanical and geological skills, not just how to run a piece of equipment. But the labour situation in SA is not well setup, there's a lot of agency on that side of things, so when the multinational companies come in, they're going to be working, I think, with some of the most precarious labour situations, and they're going to get local people, local middle managers, who know how to round up a lot of cheap folks, and not treat them very well" (participant 7)

One final observation from this experience was of the dolerite intrusions. These have been problematic in establishing any remote consensus of shale resource estimates, but they create a stunning landscape. This is an important point, as among stakeholder arguments against gas development in the region, is its potential impact on other industries and on fragile ecosystems.

3.4.7. Bloemfontein

I was invited to spend some time at the University of the Free State, Bloemfontein, and meet some of the people involved in designing and implementing the environmental baseline projects. Over the course of two days, I was able to conduct a number of interviews, and shadow members of the team (that they not only permitted this, but switched to speaking English for my benefit is a testament to their hospitality and their open approach to research).

The visit generated abundant data for the research, but also alerted me about the challenges of working in the Karoo. The geologist who was responsible for installing and maintaining the monitoring sites (these being spread over 1000s of square kilometres), was explaining the logistical challenges (*e.g.* needing a minimum of three spare tyres per trip!) and the social problems they face every day. The ongoing land ownership debate (see Expropriation Bill and the associated proposed amendment to section 25 of the Constitution), the persistently high regional crime rates, and the apartheid legacy, have not engendered the most trusting and open environment in which to conduct scientific research on an already contentious issue. The mistrust in stakeholder engagement processes has already been discussed, but an outcome of this mistrust is the importance of individual relationships between the researchers and landowners / community representatives.

3.4.8. Gauteng and Mpumalanga

This final part of my field research, apart from one follow-up interview in Pretoria with a government official, was largely intended to provide a more rounded contextual understanding of the socio-political history of RSA. As identified in section 3.4.1, I met a veteran journalist[39] in 2019, with whom I designed a trip to visit various sites and people in Gauteng and Mpumalanga. Foeta has had an eventful professional career, and experienced first-hand many of the events that have shaped South Africa's recent history, notably the Angolan civil war, conscription, the end of apartheid, the birth of democracy, and state capture. Together we travelled to meet an eclectic mix of people, including an ecologist, a former newspaper editor, a tv presenter, and various other acquaintances. We did this on the road to the scarred landscape of the Mpumalanga coal fields, the Barberton Makhonjwa Mountains geological World Heritage Site, the Cradle of Humankind World Heritage Site, and a number of other places enroute. The details of these trips are not directly related to this research, but their importance in the understanding of the situation of my work cannot be understated: something which I hope is reflected in the research composition. It is impossible to fast-track a deep understanding of a country like South Africa, with such a storied history, but a fortnight on the road with a veteran journalist and raconteur is a very good start.

[39] Foeta Krige is a veteran journalist with 37 years' experience in print media, television and radio. In 2016, as part of a group of journalists called the SABC8, he won the Nat Nakasa Award for courageous and brave journalism, as well as the Chairman's Guardian of Governance Award in 2017 from the Institute of Internal Auditors South Africa. For the past 14 years he has been the executive producer of the current affairs programmes of the SABC's Afrikaans radio station, RSG (Penguin Random House SA, n.d.).

Figure 3.8: L to R: Vandalised war memorial; J Hemingway, local worker, F Krige

3.5. Concluding remarks

The methodological approaches adopted in this research were varied. Some of this was intentional, some born out of necessity given the disruptive influence of COVID-19. The preliminary research, through a combination of luck and design, established a solid framework for further work. The interview process was largely effective, although interrupted by COVID-19, and I have provided an honest appraisal of what I believe to be its strengths and weaknesses. The document analyses were challenging, designing robust criteria for both selection and analysis was complex, although I was satisfied with the outcome. The fieldwork provided primary data, and perhaps more importantly, a contextual understanding of my research than I would otherwise not have acquired. The fieldwork was hampered to an extent by its truncated timeframe, and the occasional lack of access. The artisanal nature of social science research is exemplified in this thesis, and I hope well-received by its intended audience.

Participant #	Date	Expertise	Sector	Role	In-person / Online	Duration (mins)	Used as Primary Data (y/n)	Location of Participant	Description	Notes
1	May-20	Hydrogeology; governance; UOG	Private	Consultant	Online	45	n	Cape Town	Exploratory	
1	Dec-21	Hydrogeology; governance; UOG	Academia	Research	In-person	60	y	Cape Town	Theory-generating	
2	Jun-20	Geology; hydrogeology	Private	Director; principal geologist	Online	35	y	Bloemfontein	Problem-centred	
2	Jan-22	Hydrogeology ; governance; policy	Government	Scientific manager	In-person	120	y	Bloemfontein	Problem-centred	
3	Jun-20	Systems ecology	Academia	Policy development; research	Online	45	n	Cape Town	Theory-generating	
3	Dec-21	Governance	Academia	Research	In-person	90	n	Cape Town	Problem-centred	
4	Mar-21	Ecology	Academia	Research	Online	80	y	Pretoria	Theory-generating	
4	Dec-21	Chemical engineering; air quality	Academia	Research	In-person	120	y	Pretoria	Problem-centred	
5	May-20	Environmental law; policy development	Private	Lawyer; lobbyist; Community stakeholder	Online	30	y	Johannesburg	Exploratory; Theory-generating	

6	May-20	Engineering; gas	Government - R&D	Principal engineer	Telephone	60	n	Johannesburg	Exploratory	Withdrew consent
7	May-20	Hydrogeology	Private	Consultant	Online	60	y	North Dakota, USA	Exploratory; Theory-generating	Recording failure first half
8	Jun-20	Physics	Academia	Research	Online	30	y	Pretoria	Exploratory; Theory-generating	
9	Mar-21	Geology; hydrogeology	Academia	Research	Online	70	y	Western Cape	Exploratory; Theory-generating	
10	May-20	Scientific and Industrial Research	Private	Principal engineer	Online	25	y	Johannesburg	Exploratory; Theory-generating	
11	May-20	Groundwater	Private	Consultant	Online	50	n	RSA - unknown	Exploratory	
12	May-20	Physics	Academia	Research	Online	40	n	Cape Town	Exploratory; Theory-generating	
13	Jan-22	Hydrogeology; UOG	Academia	Research & Project Management	In-person	120	y	Bloemfontein	Problem-centred	
14	Jan-23	Midstream & Upstream Oil & Gas	Private	CEO & Executive Director	Online	60	y	Cape Town	Theory-generating	
15	Jan-23	Energy, systems transition	Private	Policy Advisor	Online	40	y	Cape Town	Problem-centred	
16	Dec-23	Political risk & Democracy	Academia	Research	Message	5	n	Namibia	Theory-generating	
17	Nov-20	Political Ecology	Academia	Research	Online	60	n	UK	Exploratory	

18	Mar-20	Hydrogeology, Geothermal Power	Public/Private	Interdisciplinary Researcher	In-person	60	n	UK	Exploratory	Not recorded
19	Jan-19	Sociopolitical and institutional dynamics of resource management	Academia	Research	In-person	60	n	UK	Exploratory	Not recorded

Table 3.1: Table showing interview participant details, and interview information

4. Paper 1: How the role of gas is framed in South African energy discourse, and the just energy transition

A B S T R A C T

South Africa is at a pivotal moment in its energy development. It is experiencing an ongoing energy crisis and has recently declared a national state of emergency. This presents the pressing problem of what energy sources can South Africa turn to in order to provide the increased capacity needed for future development, while at the same time decarbonising to fulfil its climate change commitments. This aim of this paper is to provide insight into the discourse surrounding the role of gas in South Africa's energy transition, into how the various interpretations of the just transition are applied to this discourse, and into how these approaches are being translated into policy, with an emphasis on energy security, socio-economic, and environmental narratives. The research uses the Presidential Climate Commission and its Commissioners as a framework to establish the scope of the various interpretations of the role of gas in the just transition, and in doing so identifies areas of agreement and dispute among key stakeholders. Our discourse analysis reveals that the principles of restorative, distributive, and procedural justice feature prominently in the South African energy transition narrative, but that there remain significant differences in approach to gas policy, and the interpretations of the principles of justice in the just energy transition. These differences are both among the Commission's stakeholders, and also between the Presidential Climate Commission's established principles and emerging government policy, potentially leading to areas of conflict that could delay much needed action to address the damaging energy crisis.

Keywords: Energy transitions; just energy transition; discourse analysis; natural gas; South Africa

4.1. Introduction

South Africa (RSA) is at a pivotal moment in terms of its energy development: it is experiencing an ongoing energy crisis and has recently declared a national state of emergency (SONA, 2023) owing to rolling "loadshedding" blackouts, primarily caused by the reliance on what is generally recognised as a mismanaged and increasingly run-down coal-powered electricity grid (Bowman, 2020; Esterhuyse et al., 2022). The country already has high levels of energy poverty (Koomson et al., 2022; Ye and Koch, 2021) so there are considerable political pressures to add sources of dependable, affordable, and safe energy into the country's existing energy mix. This presents a pressing problem: what energy sources can South Africa turn to in order to provide the increased capacity needed for future development, while at the same time decarbonising to fulfil its climate change commitments? In the government's framing, questions of justice are put centre stage, with the stated goal of the Presidential Climate Commission (PCC) being to achieve a "just and equitable transition to a low-emission and climate resilient economy" (PCC – Overview, 2023). Unsurprisingly there are major debates and conflicting viewpoints on how to interpret this call for a 'just transition' and what this should mean in material terms for South African energy policy development.

In this paper we focus in particular on the narrative surrounding the role of natural gas as part of South Africa's just transition. For a country that is both a major coal producer and user, natural gas ostensibly offers low carbon emissions per unit of electricity production, acting as a so-called 'bridge" or "transition" fuel in the process of decarbonisation (Delborne et al., 2020; Janzwood and Millar, 2022). Recent studies indicate that South Africa has potentially large volumes of both onshore and offshore gas reserves (Brownfield, 2016; Total, 2019), including considerable unproven shale gas reserves that could be extracted through hydraulic fracturing, or 'fracking' (de Kock et al., 2017). The use of gas, however, either as a means of transitioning to a lower carbon energy system, as a replacement for coal, or as a temporary supplementary fuel source, is controversial. This is due to the uncertainties around the green credentials of gas (Kemfert et al., 2022), which are of concern for those focused primarily on reducing carbon emissions, and the local environmental consequences of gas exploitation, particularly through fracking. Consequently, there is substantial opposition to both on and offshore gas development in South Africa (Gürsan and de Gooyert, 2021; Halsley, 2022 Kama, 2019; Tilsted et al., 2022; WWF Africa, 2023). There is also strong opposition to gas development from those representing workers currently employed in the coal mining industries, as it is perceived as a significant threat to livelihoods.

Given this context, our aim is to analyse the narrative of natural gas as part of the Just Transition in South Africa and how key stakeholders are positioning, evaluating and supporting or challenging its role. We undertake a thematic discourse analysis of publications authored or endorsed by a diverse set of actors including government departments and ministers, of business and industry, of civic society, of organised labour, of academic and research institutions, and environmental campaign groups. The analysis presented examines how the narratives of these different actors engage with the role of gas specifically, whilst paying attention to wider arguments and perspectives on the transition in a South African context.

Through our analysis we contribute to two bodies of existing work. First, energy debates in South Africa, and their political, socio-economic, and environmental narratives. Energy policy, energy poverty, and the ecological impacts of the extractive industries are well established fields of research in RSA (*e.g.* Baker et al., 2014; Koomson et al., 2022; Simpson et al., 2019), as are the areas of specific interest in energy topics such as shale gas research (De Kock et al., 2017; Esterhuyse et al., 2022; Scholes et al, 2016), the water-energy-food nexus (Conway et al., 2015), and the energy transition (Baker et al., 2014; Hanto et al., 2022). However, our analysis will provide a novel insight into the interplay of stakeholder narratives, and how these are shaping and contesting current energy policy. Second, it will expand on how gas is being politically and discursively represented within energy and transition debates around the world, including: the role of gas as a “clean” transition fuel (Delborne et al., 2020; Levi, 2013; Podesta and Wirth, 2019); its function in domestic energy security (Gillessen et al., 2019); and the potential socio-economic impacts of further gas expansion (Janzwood and Millar, 2022; McGranahan and Kirkman, 2021).

We begin by describing the current energy situation in South Africa, followed by an appraisal of the “just transition” and its varying interpretations. This highlights how South Africa’s existing socio-technical and socio-economic regimes must inform the trajectory of the just transition framework and leads to the justification for the research design methodology. The research concludes with an evaluation of this discourse analysis, demonstrating how key stakeholders are portraying the role of gas in the just transition, and the underlying justifications for their different approaches.

4.2. South African energy context and transition challenges

South Africa’s current energy mix is dominated by coal. This comprises 39.3 GW of the country’s 53.7 GW installed power generation capacity, supplying over 80% of the 227 TWh national electricity demand (CSIR, 2021; IEA, 2023; NBI, 2022b). In terms of coal energy consumption per capita, it is the 6th most coal-dependent country in the world. The coal sector is deeply embedded in the national socio-economic fabric, directly employing ≈80 000 people, and up to 400 000 other people indirectly across the value chain. This figure comprises around

3% of the national workforce, but with the added significance that each worker is estimated to have between 5 and 10 persons dependent on their salaries (NBI, 2022b). Mining, organised labour, and coal, are also firmly anchored in the national political landscape, in what is an often complex and overlapping series of alliances between politics and the trade unions (Hanto et al., 2022). President Ramaphosa was instrumental in establishing the National Union of Mineworkers (NUM) in 1982, and spent 9 years as its Secretary-General. Another of the African National Congress (ANC) "Top Seven", Gwede Mantashe, spent 8 years as NUM Secretary-General (1998-2006), and has, since 2018, occupied the position of Minister of the Department for Mineral Resources and Energy (DMRE). The NUM is the largest affiliate member of the Congress of South African Trade Unions (COSATU), which is itself part of a political compact with the ANC and South African Communist Party (SACP) (for which Mantashe also acted as Chairperson (2007-2012)), called the Tripartite Alliance.

In contrast to the dominant material (and political) status of coal, combined renewable energies (excluding hydro) comprise just ~5 GW installed capacity (CSIR, 2023; NBI, 2022b). Although South Africa is geographically well-suited to exploit wind and solar energies (Jain and Jain, 2017; Naicker and Thopil, 2019), the ability to fulfil its international energy commitments and meet domestic demand with these resources alone, would require a rapid and significant increase in capacity, which many industry insiders perceive to be unrealistic. This has led to policy-makers seeking alternative energy solutions, notably gas.

South Africa already has a small but well-established gas industry, comprising ~3.8 GW installed capacity, from 6 open cycle gas turbines (OCGTs), a large gas-to-liquids refinery, and limited pipeline infrastructure. Recent studies indicate potentially large volumes of both onshore and offshore oil and gas reserves (Brownfield, 2016; Total, 2019), which are seen by some as potential game-changers in the energy sector. As a signatory of the Paris Agreement, South Africa is committed to reduce its carbon emissions in a way that is practicably aligned with its socio-technical and socio-economic realities, and has outlined ambitious nationally determined contributions (NDCs). However, although these have been supported by several policy announcements that signify a commitment to achieving these objectives, including the Just Energy Transition Partnership (JETP) and the Renewable Energy Independent Power Procurement Program (REIPPP) (CAT, 2022; Schmid and Lumsden, 2023), the current status of RSA's progress has been classified as insufficient (CAT, 2022). Uncertainty about the government's ability to enact policy to achieve the NDC goals remains high, a fact compounded by what Climate Action Tracker (CAT) describe as the "mixed messages" being portrayed by the ANC.

In this context, it is reasonable to describe South Africa as at an energy crossroads. Whatever the balance of the future energy mix, its infrastructure requires expansion and further development, so maintaining the status quo is not an option (Andreoni et al., 2022; NBI, 2022b), but the pathway that it chooses will have a significant influence on its medium-term energy mix, its future greenhouse gas (GHG) emissions, and the socio-economic realities for those most impacted by the energy transition. In addition, given South Africa's status as a sub-Saharan superpower, its chosen pathway will inevitably be of continental if not global significance.

4.3. Just energy transition

The South African government's approach to navigating the energy transition is through the Presidential Climate Commission (PCC), which explicitly adopts a 'just transition' framing. As many analyses have shown the notion of just transition is a deeply contested one, with diverse interpretations, emphases and political rationalities (Bouzarovski, 2022; Healy and Barry, 2017). For some, particularly reflecting the emergence of the just transition discourse in the US labour movement (Smith, 2017), the primary concern is with transitioning labour in a just way, as jobs decline in carbon intensive sectors and grow in others focused on low carbon energy production and end uses (Carley and Konisky, 2020; Wang and Lo, 2021). Others cast the notion of 'justice' in transition in far broader and more fundamental terms, including multiple dynamics related to climate change policy and impacts, critiques of existing economic systems and relations and analysis across multiple scales of climate governance (Bouzarovski, 2022; Dunlap and Marin, 2022). Within the energy field specifically there has been some emphasis on systemizing categories of justice meanings that are important to transition processes, building on earlier environmental justice conceptualisation (Walker, 2012). Most dominant has been a perspective that sees justice in terms of the three 'tenets' of distributive justice, procedural justice and justice as recognition (Bouzarovski 2022; Jenkins et al. 2018), although recent critiques have challenged misinterpretations in particular of 'justice as recognition' and of the approach as failing to address underlying socio-economic and political forces that create and perpetuate energy injustice (Bouzarovski and Simcock, 2017; Lee and Byrne, 2019)

Within the overarching Justice Transition Framework set up by the South African Presidential Climate Commission (Just Transition Framework, 2022), there is some explicit mirroring of justice principles, these being specified as distributive justice, procedural justice and restorative justice (rather than justice as recognition). In our later thematic analysis, focused specifically on the role of gas, matters of distributive and restorative justice will feature directly, with various interpretations being deployed. Procedural justice figures less explicitly in our analysis, in part because it is embedded more generally both within principles and procedures laid down in the South African Constitution and related legislation (*e.g.* the Bill of Rights, and the National Environment Management Act 107 of 1998), and also within the overall setting up, process, and practice of the PCC.

Distributive Justice	Restorative Justice	Procedural Justice
Equipping South Africans with skills, assets, and opportunities to participate in industries of the future, with particular attention on impacted groups, the poor, women, people with disabilities, and the youth.	Acknowledging the health and environmental impacts to communities in coal and other fossil fuel impacted areas, and supporting all South Africans' constitutional rights to a healthy environment.	Assisting communities to understand what the just transition entails, specifically, and discuss points of agreement and disagreement openly and transparently.
Implementing transformative national economic and social policies that clearly consider how benefits and burdens will be distributed (this includes clear indication of where jobs are gained, where jobs are lost, and the quality and longevity of future employment).	Shifting away from resource intensive sectors and fossil fuels to (1) improve ecosystems with community ownership and stewardship, (2) improve energy security and eliminate energy poverty, and (3) create opportunities for rehabilitation of degraded land, air sheds, and water systems, the improvement of biodiversity, as well as related employment opportunities	Supporting worker and community organisations (unions, civics, advocacy groups, etc.) to participate actively in just transition policy-making processes ensuring decisions are made in their best interests and allow them to take advantage of opportunities.
Increasing provincial and local capacity (both resources and skills) to promote local economic development.	Creating a more decentralised, net-zero-emissions economy, which allows for greater economic inclusion, ownership, and participation, especially for women and the youth.	Collaborating actively with a range of stakeholders, through inclusive and participatory decision-making structures, allowing each to play to their respective strengths, fostering a

		more dynamic, competitive, diversified, and equitable economy
Ensuring corporate responsibility to support a green and inclusive economy	Remedying past harms by building on, and enhancing, existing mechanisms such as equitable access to environmental resources, land redistribution and Broad-based Black Economic Empowerment	Supporting the design and implementation of just transition projects, as proposed by individuals and communities in affected areas.

Table 4.1: Principles of justice as explicitly outlined by the PCC (PCC, 2022 pp 8-9)

The PCC is a 'multi-stakeholder' vehicle, with that being seen to be a just and inclusive approach and to bring credibility both through the broad expertise and representation of its commissioners (see table 1) and its prestige as a presidential body, in principle facilitating the intergovernmental cooperation needed throughout the transition (Connolly, 2022). The PCC has produced several detailed reports, and has hosted a number of stakeholder engagement events, in-line with its commitment to transparency and public participation (Connolly, 2022). Part of the objective here is undoubtedly to try and build a sense of fairness in the process being used and a 'social compact' for the way forward. By facilitating a representative approach to decision-making processes policy-makers might build a social licence to operate, although how real this might be in practice will always be open to dispute (Connolly, 2022; Sovacool et al., 2017). Seeking this social licence is particularly relevant in the South African context, given the constitutionally enshrined right of access to court. There have been several successful high-profile challenges to government policy directly relevant to gas and the just transition in recent years, led by civil rights organisations, unions, and advocacy groups,[40] which raises the question as to whether the PCC can help avoid protracted legal challenges to policy in the future.

[40] Minister of Mineral Resources v Stern and Others; Treasure the Karoo Action Group and Another v Department of Mineral Resources and Others (1369/2017; 790/2018) [2019] ZASCA 99; [2019] 3 All SA 684 (SCA) (4 July 2019); Sustaining the Wild Coast NPC and Others v Minister of Mineral Resources and Energy and Others (3491/2021) [2022] ZAECMKHC 55; 2022 (6) SA 589 (ECMk) (1 September 2022);

4.4. Methods

Given there is an established coalition of social partners engaged in the just transition process, there is a robust focus for document analysis, which provides methodological transparency for document selection (Jacobs and Tschötschel, 2019; Mackieson et al., 2018). The timeframe adopted for analysis included documents published after the establishment of the PCC, *i.e.* between January 2021 up to and including the 2023 State of the Nation Address (SONA) and relevant reaction to the address. Two exceptions were made to this window, the 2019 Integrated Resource Plan (IRP), as it is the most relevant formal policy document to date, and the groundWork “Down to Zero" report (2019), as it represents a significant and relevant contribution from the third sector associated with the Commission.

Resolving the data selection process required a flexible approach because the roles of the commissioners are not uniform. For instance, some commissioners are acting from a personal capacity, others represent government ministries, and some are there as professionals representing groups or organisations. The method of data collection, therefore, reflected this diversity. The initial process involved analysing publicly-accessible documents that were either published by commissioners or on their behalf, published by the groups the commissioners represent, or statements made publicly by commissioners to media outlets in a personal capacity. Once documents were identified, a keyword search was conducted to establish their relevance, including: *gas, LNG; shale; just transition; energy; energy policy.* In the instances where annual government speeches were relevant, all documents were included to add an (albeit short) temporal component to the analysis. This process totalled 37 documents relating to 16 commissioners (see appendix i).

Finally, a qualitative thematic document analysis was carried out using f4analyse software. The qualitative aspect of the methodology involved examining the documents for their references to natural gas and its role in the just transition, particularly how these references are framed in relation to the characteristics identified in section 3 and more broadly how they are situated within the PCC’s own framework of procedural, distributive, and restorative justices.

Section 5 discusses the findings through energy security, socio-economic and environmental themes.

4.5. Perspectives on the role of gas in the RSA transition

To frame the discussion, this section will provide an overview of the governmental position on the use of gas in the energy transition as evident in the document analysis. The ANC are clear in their resolve for gas to be a component in its future energy mix. This is explicitly stated by President Ramaphosa, as one of his five “key interventions” is to:

> “Accelerate procurement of new capacity from renewables, gas and battery storage” (SONA, 2023)

This stance is reflected by another leading figure in the ANC, Mr. Mantashe, who framing the future demand for energy alongside the just transition, sees gas as a:

> “Critical primary energy source for South Africa to meet this demand while on the just transition journey” (Mantashe - Africa Energy Week, 2022)

This position on the use of gas is of longstanding. It has been reiterated by President Ramaphosa in all three SONAs examined within the scope of this research, is present in the IRP(2019), and includes the potential to exploit both on-shore and off-shore reserves, alongside increasing imports. It is also envisioned by the ANC that this approach will be adopted by other African countries, rationalising the argument to a wider geography and pan-African ‘need‘ for gas extraction:

> “Countries on the African continent need to be able to explore and extract oil and gas” (Ramaphosa - Investing in African Mining Indaba, 2022)

Given the absence of an updated formal policy, specifically a revised Integrated Resource Plan, it is impossible to say with certainty the extent to which gas will feature in the future energy mix, but these statements, alongside other material discussed later, demonstrate clear intent from the ANC to pursue gas as an additional fuel source in the near future. This conclusion is shared by the Democratic Alliance, in what they describe as Mantashe‘s “stubborn[ly] advocacy” for coal, gas, and nuclear (Mileham, 2023).

The justification for this approach structures the following discussion, moving through energy security, socio-economic considerations, and environmental arguments, each with substantial additional elements that incorporate dimensions of restorative and distributive justice. Within these broad themes the numerous and diverse positions and counter-positions of different stakeholders are examined, along with the series of overlapping and often conflicting alliances and divergences formed between them.

4.5.1. Energy security

Broadly speaking, the electricity system can be categorised as either bulk supply (sometimes referred to as baseload or firm power), providing the cheapest energy, peaking supply, to be used in periods of high demand, and a balancing or back-up system, to fulfil supply deficits (IISD, 2022).

The ANC are clear in their position that energy security, and particularly base-load energy requirements, cannot be met by renewables alone. This position provides the basis for their inclusion of additional non-renewable energy sources into the national energy mix, presenting this as a necessity rather than choice, In some instances a crisis narrative is deployed to make apparent the threat to energy security:

> "Cognisant that renewables do not provide baseload, we must increase investments in alternative energy sources that will provide the baseload energy needed to ensure uninterrupted energy supply. This is critical during the transition" (Mantashe - The National Energy Dialogue, 2022)

> "We ought to guarantee baseload energy supply through a combination of gas, nuclear, coal, and hydro. A pendulum swing from coal powered energy generation to renewable energy does not guarantee baseload stability. It will sink the country into a baseload crisis" (Mantashe - JET debate, 2022)

While it is undeniable that current renewable capacity in RSA cannot provide bulk supply, the need to use new gas resources to fulfil this role in the future is not widely shared, either by non-governmental commissioners, the PCC itself, or many within RSA's scientific research community (*e.g.* CSIR (Clark et al., 2022)). The most recent draft recommendations published by the PCC state that "international experience shows that renewable energy-dominated systems are stable" (PCC-Electricity Planning, 2023 p 67) and the PCC commissioners express a broad range of opinions on this fundamental issue.

The position of organised labour on the increase of gas as a bulk supply option is not uniform, but is mostly opposed to its inclusion; NUMSA are explicit in their commitment to coal as their near-term bulk supply of choice, but they endorse the ANC position that renewables cannot meet current demand:

> "The NUM's position is that coal mines must be left alone" (NUM, 2023)

> "South Africa needs a sustainable and reliable energy baseload, and that's the starting point. You cannot power the economy on renewable energy" (NUMSA, 2022)

FEDUSA go further, potentially ruling out any support for gas as part of the energy mix:

> "In the transition of the energy mix, rather than the exploitation of fossil fuel gas, FEDUSA prefers the extension of the lifespan of coal mines, coal-fired electricity plants and Sasol's coal-to-liquids plants" (FEDUSA, 2021)

COSATU remain somewhat ambiguous, acknowledging the need for gas as a part of the future energy mix, but without specifying in what capacity. They instead focus on more procedural aspects, notably regarding ownership, and the re-skilling of workers (COSATU, 2022).

In contrast, the NBI have produced detailed plans for how they envisage gas being utilised in a series of publications, which outline the need for gas in a peaking and balancing capacity, with investment required in new gas infrastructure, notably floating storage. They do however rule-out the need for gas as a bulk fuel, and consequently the development of new gas fields:

> "This study does not see the need for baseload gas, with utilisation >50% in the South African power system, as it is neither the least-cost approach nor a technical requirement for system stability" (NBI, 2022a)

Finally, commissioners that can be broadly grouped as the green cohort (see table 1) are unanimously opposed to any increase in gas use for enabling energy security, even as a short-term measure. They argue that measures such as those proposed by the NBI will not provide the solution to short-term energy deficits, rather that the flexibility of renewable energy is an important asset:

> "We already know the solution to load-shedding. It lies primarily in flexible, dispatchable renewable energy" (CER, 2023)

Beyond members of the PCC, there is also significant disagreement about the function that gas could / should fulfil in relation to energy security. The CSIR are broadly aligned with the position outlined by the NBI, suggesting that gas would not fulfil their least-cost requirements as a baseload feedstock, and instead should be utilised to complement peaking capacity (Clark et al., 2022; Wright and Calitz, 2020). It is also argued by certain proponents of RE, that the baseload-peaking model is itself outdated, and offer alternatives to what they describe as the "baseload fallacy" (Gets, 2013 p. 15). A "smart grid" alternative is instead proposed, whereby small-scale RE are integrated into a decentralised system that can track and manage supply and demand in real-time and distribute capacity accordingly (Gets, 2013; Halsley et al., 2022; Lawrence, 2020).

Given these counter-arguments against gas as being crucial to energy security, what further justification do the ANC provide for their position? The ANC regularly frame long-term energy security as an issue of international contest, with international actors exerting pressure on the African continent:

> “The Just Energy Transition debate is a complex and contested terrain in which countries across the globe seek to advance their own national interests” (Mantashe - JET debate, 2022)

> “However, Africa must not succumb to the encirclement by the developed economies which continue to put pressure on our continent to move away from all forms of fossil fuels at a pace and scale determined by them” (Mantashe - Africa Energy Indaba, 2023)

In this context, the focus of energy security and the energy transition is re-framed as an issue of self-determination (and therefore of procedural justice understood in national-continental terms). To this end, the ANC clearly link natural gas to the future socio-economic progress of the nation, mobilising long-standing distributive justice arguments about the rights of nations in the Global South and Africa specifically to sustain resource exploitation (including fossil energy resources) for economic reasons, rather than accede to arguments for not doing so. In this extract the conjunction between resource endowment and baseload is clearly made:

> “Africa is endowed with resources such as coal, oil and gas which are needed for baseload energy to power our industrialisation” (Mantashe - Africa Energy Indaba, 2023)

The ministerial components of the Commission are not alone in their geo-political energy stance, the NUM adopt a similarly combative position, appealing both to African solidarity and to resistance to outside and unwelcome interests:

> “The National Union of Mineworkers (NUM) is in support of the Mineral Resources and Energy Minister Gwede Mantashe on his call for Africa to unite against 'coercion' by the global anti-fossil fuel agenda” (NUM, 2023)

The ANC’s position on energy security, which as shown above, is often presented as being determined by domestic and continental self-reliance, suggests they are sceptical about the outcome of international commitments (*e.g.* the UN Framework Convention on Climate Change principle of common but differentiated responsibilities), and about the tenet of restorative justice outlined therein; that the financial burden of the energy transition must be covered by those historically responsible for the problem (although these are stated as provisions in the PCC framework p. 8). This mistrust provides justification for the exploration of alternative pathways that include gas. It should also be noted that this scepticism is shared by those commissioners that represent the ’anti-fossil fuel‘ agenda. Naudé (2022), notably acknowledges the threat to self-sufficiency as a potential barrier to the roll-out of RE, arguing that the financing terms (*i.e.* interest-bearing loans) of the JETP are incompatible with agreed international principles, and will hinder the energy transition.

4.5.2. Socio-economic

The ANC express a clear view on the potential for indigenous gas to fuel socio-economic development arguing that it will create jobs, provide revenue, and enable wealth distribution, pointing to its 'huge potential' (SONA, 2022). The mechanism by which each of these promises will be achieved is less clear, and individually these claims have been met with scepticism by stakeholders in the PCC

The actual number of jobs that could be created is highly speculative, primarily owing to the unresolved issue of recoverable volumes of on-shore and off-shore gas reserves (De Kock et al., 2017). These unknowns do not however prevent detailed estimations. The ANC have not proposed their own figures, and instead favour an approach that promotes exploration first, with a future promise of job creation either implicitly or explicitly included their proposals:

> "It is the view of the Department that the development and optimal use of our indigenous resources will help re-industrialisation, manufacturing and ultimately job creation" (Mbele – Oil and Gas Colloquium, 2022)

This approach has been widely criticised, as without detailed proposals and a transparent appraisal of the models employed, and their differing methodologies, it is difficult, if not impossible to make informed decisions between alternative available pathways, and their comparative socio-economic merits. This state of uncertainty regarding job creation is a significant source of conflict between stakeholders.

The absence of detailed socio-economic projection being provided by the ANC is highlighted by the green lobby within the PCC, challenging the ANC's job creation narrative and arguing that RE provides greater job opportunity:

> "Employment opportunities linked to any energy carrier must be compared with all the candidate energy carriers that can address adequate energy supply. Many studies and global experience show that renewable energy technologies can provide much wider employment than fossil fuels. For South Africa, this difference would be most wide between indigenous renewable energy – our natural endowment – and imported fossil gas" (WWF, 2021)

However, Mantashe has in turn expressed scepticism about the ability of RE to generate the number of jobs the green lobby claim is possible, and in doing so accuses the lobby of misrepresentation. Following a visit to a wind farm, which he claimed to have only five employees, he states:

> “I want these experts to explain to me, how are these jobs going to be created? We must not be abstract about what solutions we are looking for, and that is not an argument against transitioning to low carbon emissions. It’s an argument against distorting information to convince everybody else” (Mantashe – Africa Energy Indaba, 2022)

Given the NBI’s argument in favour of minimal gas expansion, and no new exploration, they instead focus their attention on job retention rather than expansion within the gas sector. They estimate that there are between 46000 – 56000 people currently employed across the gas value chain in RSA, and that although it represents a small percentage of the energy mix, nonetheless has considerable existing socio-economic value, comprising 1 – 2% overall GDP contributions (NBI, 2022a):

> “Gas can […] yield socio-economic benefits like maintaining jobs and economic activity in key sectors, such as the petrochemicals sector for example” (NBI, 2022a)

There has been an extensive scientific assessment of opportunities and risks regarding shale gas development in the Karoo region (Scholes et al., 2016), which explored potential job creation within different gas volume scenarios. The authors concluded that within their “big gas” scenario (20 Tcf), fewer than 3000 direct jobs would be created, of which only 15-35% would be provided by local employers (Scholes et al., 2016). This study, although the most comprehensive research conducted to date covering shale gas in RSA, has been largely ignored by ministers, most likely because its ‘big gas’ scenario remains 10 times smaller than the government endorsed estimate of recoverable gas volumes.

Until more detailed policy proposals are made, the debate around job potential in the sector will remain largely hypothetical. However, this absence of detail is being exploited by opponents of the overall policy, to create a starkly contrasting narrative to that of gas as a socio-economic boon:

> “As noted in the groundWork Report 2020, there is considerable scepticism concerning the shale gas reserve. As usual, government exaggerates the benefits, particularly for jobs, and understates the costs, particularly relating to water in this arid region. As with offshore exploration, considerable damage can be done on the way to finding nothing much” (groundWork, 2022)

This position has found success in the courts; in the case of Sustaining the Wild Coast and others against the Minister of Mineral Resources and Energy and others, High Court Eastern Cape Division, Case no. 3491/2021, the court upheld the need to substantiate socio-economic claims, and in not doing so, is failing to comply with applicable legal prescripts:

> “Much as there were statements made in the EMPr that the seismic survey would create jobs and increase government revenues etc, no detail to substantiate these claims is made; no explanation as to how the jobs will be created, and how the economy will be stimulated, or how the seismic survey will improve the socio-economic circumstances in which most South Africans live are provided”

Beyond the crude metric of numbers of jobs created, there are also a number of other factors regarding employment that are addressed by stakeholders, notably the types of job created, their permanence, the spatial distribution of new employment, and the existing gendered and racial disparities in the extractive industries. This concern is reflected by all members of the Commission, and is outlined in the PCC’s embodied distributive justice principles as:

> “Implementing transformative national economic and social policies that clearly consider how benefits and burdens will be distributed (this includes clear indication of where jobs are gained, where jobs are lost, and the quality and longevity of future employment)” (PCC. 2022)

This sentiment is reflected by the NBI:

> “Jobs are not created equally across South Africa’s geographies and across time frames, and can also not necessarily “absorb” workers who have lost their jobs in the context of the Net-Zero transition, due to lack of required skills” (NBI, 2022b)

The spatial aspect of distributive justice is particularly relevant in South Africa. First, because of the ongoing spatial legacy of apartheid, and the resulting concentration of poverty, energy poverty and infrastructural deficit in former homelands and urban townships (Noble and Wright, 2013). Second, because the coal mining industry is concentrated in the north-eastern part of the country, so the impacts of transition will be felt most acutely in these states (NBI, 2022b).

However, some members of the Commission strategically use such spatial differentiation to bring the concepts of distributive and restorative justice to the fore in their counter-arguments, suggesting that gas will not provide meaningful long-term employment benefits, and noting that historical experience of employment distribution in the extractive industries has been inequitable:

> “Jobs are promised to affected people but not delivered except for basic labour during construction. Higher paying skilled jobs are generally reserved for expatriates housed in enclaves separate from the local people and contributing nothing to local economies” (groundWork, 2022)

> “In addition to the historical marginalisation of Black workers in the early development of the electricity sector in South Africa, women across the board have been largely excluded and sidelined from the bulk of decent work opportunities in the sector” (COSATU, 2022)

DMRE have also made spatially structured arguments across a broader scale comparing South Africa’s resistance to multinational oil companies to their welcoming in neighbouring countries. Discovery of reserves is equated with success and the green lobby is accused of making ‘an island of angels’ hampering South Africa’s progress through naïve and misplaced moral arguments:

> “The companies that are making the finds in Namibia have been harassed out of South Africa, because we want to be an island of angels in a sea of poverty. It’s the most dangerous strategy for us in South Africa, Shell, we chased out …of the Eastern Cape and it goes and makes a huge find next door in Namibia… Eni, we chased out in KwaZulu-Natal, they went to Côte d’Ivoire and made huge oil finds… I’m sure if we do that exploration, we’re going to be a different country” (Mantashe - Africa Energy Indaba, 2022)

This position is in turn challenged both by the green lobby and union representation within the PCC, instead arguing that existing oil and gas development across the African continent has further embedded poverty and distributional inequality rather than alleviate it, and furthermore, creates potential for conflict. For example:

> “Extractivism focused on fossil fuels has in fact brought pollution, poverty and violence to African countries and communities. Extractivism digs countries into debt, not out of debt, as the ruling elites take on debt against future revenues” (groundWork, 2022)

> “Given the levels of conflicts that have emerged in Mozambique over control of gas reserves, increased inclusion of gas technologies may drive interest in aggressive state and local capital intervention in the region” (COSATU, 2022)

Given the starkly contrasting appraisals of the socio-economic potential of regional gas development, it is likely the conflicting narratives will persist in both debate and the judiciary. Further, the ANCs policy of pursuing exploration without explicitly outlining what discovery would lead to (as *e.g.* Scholes et al., 2016 attempted) means the debate is likely to remain at an abstract level. This may be to the advantage of the ANC and other advocates of gas development, as generalised anticipatory promises may be more effective rhetorically than the detail of particular scenario assessments.

4.5.3. Environmental

The environmental impact of gas development is identified by the Commission, and again, the appraisal of risk varies widely between stakeholders. Alongside energy security and socio-economic benefit arguments, the ANC also present gas as a means of reducing carbon emissions, and achieving international environmental commitments. They argue that gas will function as a lower carbon transition fuel (or bridge fuel), between existing coal production, and the end objective of net-zero, and one which will also facilitate security and development objectives:

> "Gas is one of the significant milestones in the country's drive to reduce carbon footprint" (Nkabane -SAOGA conference, 2022)

> "Growing consensus supported by technical studies that for South Africa to achieve its targets to reduce emissions in the electricity sector through the deployment of renewable energy, gas is part of the options necessary to support the network and ensure security of supply" (Nkabane -SAOGA conference, 2022)

This position they claim has regional and international support. By identifying existing international policies, and highlighting historical injustice, both in terms of responsibility for the climate crisis, and the advantage that developed economies have achieved throughout their fossil-fuel powered industrialisation, they present an argument that justifies the global environmental impact of gas development in RSA:

> "We are expected to move quick towards a low carbon emission era, despite the fact that the "accused" in this case are the developed economies, Africa is at the bottom of the pollution barometer [sic]" (Mantashe - Africa Energy Indaba, 2022)

This approach to the transition process has been reiterated by Mantashe on a number of occasions, resisting what he refers to as the "pendulum swing" from coal to RE, and instead framing the transition as a journey, and gas as a bridge or fuel necessary for its successful completion:

> "We are expected to fast-forward to where developed economies are, as if we can reach that stage without travelling the journey. The reality is we will reach that stage, but we have to travel the journey" (Mantashe - Africa Energy Indaba, 2022)

However, Within the Commission, only the NBI broadly accepts the role of gas as a transition fuel, and one which it proposes will contribute to carbon emission reduction. For both the labour and green factions, the bridge fuel argument has come under intense scrutiny, with critique oriented to different scales of consequence. First, from a broad, global, environmental perspective, the green lobby in particular dispute the claim that gas is a clean fuel:

> "Methane emissions and concentrations in the atmosphere have been rising rapidly in recent years. Leaks from oil and gas production, notably from gas flare failure and fracking, are the most significant sources of this increase" (GroundWork, 2019)

> "Fossil gas is not a necessary part of the energy transition, and is not a more climate-friendly fossil fuel" (WWF, 2021)

Second, they identify the potentially deleterious local and regional consequences that could result from gas exploration and production:

> "The climate, water and ecosystem impact of expanding fossil gas extraction is irreversible, and the impacts upon surrounding communities including in neighbouring countries are very negative" (FEDUSA, 2021)

> "Investing in gas as an energy source in South Africa is unnecessary, economically risky and poses public health and climate change threats" (CER, 2022)

This point is reiterated by the agricultural lobby, who stress the potential for conflict over water use rights between the energy and agricultural sectors which will be unmanageable in an already water-stressed environment:

> "The inescapable reality is therefore that South Africa cannot accommodate a highly water consumptive and polluting onshore gas industry" (AgriSA, 2022)

The concept of gas as a transition fuel is also disputed for its capacity to obstruct the development of cleaner alternatives. Two arguments figure here in stakeholder discourse. First, that rather than creating a smooth transitional pathway, the introduction of further fossil fuels into the energy landscape will create an unfavourable economic environment for new RE, for example, Greenpeace contends that:

> "These plans will lock in greenhouse gas emissions and will crowd out space for least-cost renewable energy" (Greenpeace Africa, 2022)

Second, that rather that being a transition fuel, the development of gas resources would become the destination, and prolong national reliance on fossil fuels, and that the concept itself is a pretext to facilitate further fossil fuel development (Kemfert et al., 2022). This position is taken by both union and green representatives:

> "[RE] avoids the country embarking on a dead end of yet another fossil fuel and avoids the risk of a supposedly 'transition' energy carrier becoming a destination" (FEDUSA, 2021)

> “Both the entry of “clean coal” and gas technologies have received criticism from environmental organisations as maintaining and extending the harmful dependence on fossil fuel generation” (FEDUSA, 2021)

The justifications for these criticisms are primarily that investment in gas, particularly investment in its associated infrastructure is economically unsound, as there is a high risk of stranded assets when the transition to renewable energies eventually occurs, and investment would “lock-in” future gas use, thereby hindering climate targets and RE rollout:

> “Much progress has been made in 2022 to move South Africa’s just transition away from dirty coal to renewable energy – in a way that also avoids the risk of getting locked into gas” (CER, 2022)

> “Gas as the transition energy; We can only challenge these Trojan horses together” (GroundWork, 2019)

The PCC has a strong environmental lobby, but their concerns about the implications of the role of gas as a part of the energy transition are largely ignored by the ministerial component of the Commission. The ANC have categorised gas as a “clean fuel”, and frame its inclusion in the energy transition as a necessary step if RSA is to achieve its climate objectives, and fuel economic and industrial growth. The justification for this position is largely based on international categorisations and comparisons, and does little to address local environmental concerns. The restorative justice principles outlined by the PCC have a strong environmental focus. If implemented, these principles would provide an opportunity as both a means of redress for past harms, and as a post-hoc methodology to prevent future damage *e.g.* by the mandating of social and environmental impact assessments prior to any development (Lacey-Barnacle et al., 2020; Siciliano et al., 2018). However, their limited prominence in government discourse creates a significant rift between the PCC’s stated principles of restorative and procedural justice, and proposed government policy.

4.6. Conclusion

This aim of this paper is to provide insight into the discourse surrounding the role of gas in South Africa’s energy transition, into how the various interpretations of the just transition are applied to this discourse, and into how these approaches are being translated into policy, with an emphasis on energy security, socio-economic, and environmental narratives. The research uses the PCC and its Commissioners as a framework to establish the scope of the various interpretations of the role of gas in the just transition, and in doing so identifies areas of agreement and dispute among key stakeholders.

The role of gas as part of the energy transition is inevitably subject to the socio-economic and socio-technical realities of a given country (Cantoni et al., 2018), and this research has identified a number of characteristics that are distinctive to RSA. The ongoing energy crisis inevitably puts pressure on the government to address the energy deficit, and as this research has shown, the concept of energy security and self-sufficiency are deeply engrained in the discourse, and particularly within the ministerial component of the Commission's promotion of, and justification for, gas exploration. The ANC broadly frames the role of gas and energy security in two ways: 1: as a necessity in achieving baseload stability; and, 2: as a means of addressing and mitigating historical injustices. By embracing gas in the short-term, as many rich nations continue to do, and by exploiting the pan-African "natural endowment" of fossil fuels, it is proposed RSA will be able to address short-term energy demands, reduce exposure to volatile overseas energy markets, power regional industrialisation, and fund development. It is being claimed that objections to this approach are driven by developed economies seeking to determine the trajectory and time-frames of the transition pathways of developing economies, while simultaneously ignoring the embedded historical injustices, and avoiding meaningful or significant engagement in restorative justice, particularly regarding financing of the transition (García-García et al., 2020; Lawrence, 2020; Naude, 2022). This multifaceted approach to energy security inevitably provokes a diverse response from stakeholders, but significantly, the ANC's assessment stands alone in its appraisal of indigenous gas extraction being a necessity if energy security is to be achieved, and also of the likelihood of gas being able to provide short-term benefits, particularly owing to a lack of existing gas infrastructure.

The socio-economic arena is no less contested. That gas has had, and continues to provide, significant financial benefits internationally is not in question, so the key areas of contest identified in this research are whether it is likely that RSA will be able to replicate these financial returns, and whether pursing a socio-economic development pathway dependent on fossil fuels is desirable. Although the ministerial component of the Commission promotes the potential of gas as a driver of socio-economic development, the volume of recoverable gas, both onshore and offshore, remains undetermined (De Kock et al., 2017), and therefore, detailed socio-economic assessments are largely missing from the discourse. What emerges from this absence is competing narratives. Ministers provide a comparative discourse, emphasising the economic benefits achieved elsewhere, both in developed nations and in Africa, while those Commissioners representing business, environmental, and labour concerns promote alternative pathways. NBI's position that investment in gas industries will create jobs, is qualified with the significant caveat that jobs will not be created equally, a position mirrored by labour representatives concerned about the impact this potentially unequal development pathway will have on its members. These concerns are explicitly addressed in the PCC's principles of distributive and procedural justice, but until formal policy is finalised, how these principles will be implemented is unclear. The environmental lobby component of the Commission also uses a comparative narrative to promote its position, but instead of comparative benefits, highlights the potential damage associated with fossil fuel exploitation. Their focus is broadly centred on the barriers that pursuing gas as development pathway will create in addressing historic injustices, including the national debt, and the engrained inequalities in wealth distribution associated with race, gender, and the complex socio-spatial legacy of apartheid (Bouzarovski and Simcock, 2017; García-García et al., 2020; Noble and Wright, 2021). It is therefore argued that socio-economic restorative justice would be better facilitated by the rapid rollout of RE.

The role of gas as a bridge fuel between a coal-based energy system and one dominated by RE remains a contentious issue worldwide (Delborne et al., 2020; Gillessen et al., 2019; Janzwood and Millar, 2022) . While the ministerial component of the Commission identifies this approach being adopted in developed nations, while maintaining their commitment to international climate targets, and argues that it provides justification for their approach, it does little to reduce the internal objections to the bridge-fuel concept. Opponents remain emphatic in their opinion that investment in gas will both "lock-in" gas as a significant part of the energy mix for years to come, and will also crowd out investment in the RE sector, thereby hindering established emission targets. There is moreover concern among stakeholders, particularly from the agricultural and green lobbies, that the ecological impact of gas development, both onshore and offshore, will be detrimental at a local level, precluding other environmental and developmental targets.

The PCC vehicle has outlined ambitious objectives, with clear guiding principles. Their commitment to stakeholder participation, and the rapid enactment of the Commission is admirable. However, the role of gas in the energy transition highlights a clear distinction between ANC policy and the PCC's stated objectives, with the result that they seem to be running on parallel rather than integrated trajectories. This divergence is particularly evident in the different framings of restorative justice, with the PCC focussing on addressing the environmental damage caused by past and existing fossil fuel exploitation, and its related social injustices, while the ANC are more focussed on globally structured historic injustices, with their economic and developmental inequalities. It seems then that the ANC's commitment to gas development is creating a scenario where the tenets of procedural justice outlined by the PCC are being sidelined, and instead of participatory, inclusive decision-making processes, energy policy is being driven by centralised government mandate. This scenario is likely to further exacerbate the ongoing energy crisis, as these decisions will inevitably result in protracted legal battles between stakeholders. This will delay much-needed action to address the damaging energy crisis.

4.7. References

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4.8. Appendix

Document title	Sector	Organisation	Author and Role	Related Commissioners	Date	Document type	Available at:
Minister Gwede Mantashe addresses ENLIT AFRICA (Mantashe – ENLIT Africa, 2023)	Gov	DMRE	G Mantashe (Minister DMRE)	G Mantashe	May-23	Speech	https://www.esi-africa.com/africa/sas-energy-mix-must-include-nuclear-oil-and-gas-as-we-need-power-now-gwede-mantashe/
Remarks by The Honourable Minister of Mineral Resources and Energy Mr Gwede Mantashe (MP) at the Africa Energy Indaba (Mantashe - Africa Energy Indaba, 2023)	Gov	DMRE	G Mantashe (Minister DMRE)	G Mantashe	Mar-23	Speech	https://www.dmr.gov.za/news-room/post/2027/remarks-by-the-honourable-minister-of-mineral-resources-and-energy-mr-gwede-mantashe-mp-at-the-africa-energy-indaba
NUM supports minister Gwede Mantashe's stance on fossil fuel (NUM, 2023)	Union	NUM		M Mbodi	Mar - 23	Press release	https://num.org.za/News-Reports-Speeches/ArticleID/1234/NUM-supports-minister-Gwede-Mantashe%E2%80%99s-stance-on-fossil-fuel

Remarks by the Honourable Minister of Mineral Resources and Energy Mr Samson Gwede Mantashe on the occasion of the SONA Debate (Mantashe – SONA debate, 2023)	Gov	DMRE	G Mantashe (Minister DMRE)	G Mantashe	Feb-23	Speech	https://www.gov.za/speeches/minister-gwede-mantashe-state-nation-address-debate-14-feb-2023-0000 (Accessed: 09 November 2023).
State of the Nation Address (SONA, 2023)	Gov	President	C Ramaphosa (President RSA)	C Ramaphosa	Feb-23	Speech	https://www.gov.za/speeches/president-cyril-ramaphosa-2023-state-nation-address-9-feb-2023-0000 (Accessed: 09 November 2023).
Desperate times call for sober thoughts (CER, 2023)	Campaign	CER		M Fourie	Feb -23	Press Release	https://cer.org.za/news/melissa-fourie-desperate-times-call-for-sober-thoughts-2
Civil society and community organisations to challenge Sasol over insufficient decarbonisation plans and ongoing pollution (Greenpeace Africa, 2022)	Campaign	Miscellaneous		B Peek; M Fourie; M Lekalakala	Dec-22	Press release	https://www.greenpeace.org/africa/en/press/52852
Fighting for a just transition to a fossil-free future (CER, 2022)	Campaign	CER		M Fourie	Dec-22	Press release	https://cer.org.za/news/2022-fighting-for-a-just-transition-to-a-fossil-free-future
South Africa's Net-Zero Transition (NBI, 2022c)	Business	NBI		J Yawitch	Dec-22	Technical report	https://www.nbi.org.za/report/south-africas-net-zero-transition/

Remarks by Minister Mantashe during parliamentary debate on Just Energy Transition (Mantashe - JET debate, 2022)	Gov	DMRE	G Mantashe (Minister DMRE)	G Mantashe	Nov-22	Speech	https://www.energy.gov.za/files/me dia /speeches/2022/jet%20debate%20i n% 20parliament%20speech.pdf
Business and social partners collaborate to progress Mpumalanga's Just Transition and drive large-scale, socio-economic development (SASOL, 2022)	Business	SASOL		S Harrington	Nov-22	Press release	https://www.sasol.com/media-centre/media- releases/ business-and-social-partners-collaborate-progress -mpumalangas-just-transition-and-drive-large-scale
Minister Enoch Godongwana responds to media reports regarding Eskom remarks (Gondongwana, 22)	Gov	Treasury		E Godongwana	Nov-22	Press release	https://www.gov.za/speeches/minis ter-finance-enoch-godongwana%E2%80%99s-response-media-reports-regarding-his-remarks-about
Remarks by the honourable Minister of Mineral Resources and Energy Mr Gwede Mantashe Africa Energy Week (Mantashe – Africa Energy Wek, 2022)	Gov	DMRE	G Mantashe (Minister DMRE)	G Mantashe	Oct-22	Speech	https://www.energy.gov.za/files/me dia /speeches/2022/Remarks-by-Minister-at- Africa-Energy-Week-18102022.pdf
Remarks by the honourable Minister of Mineral Resources and Energy Mr	Gov	DMRE	G Mantashe (Minister DMRE)	G Mantashe	Oct-22	Speech	https://www.energy.gov.za/files/me dia /speeches/2022/Africa-Oil-

Gwede Mantashe Africa Oil Week (Mantashe – Africa Oil Week, 2022)							Week2022-Opening -Speech-by-Minister-04102022.pdf
Just transition finance should be grants, not loans (Naudé, 2022)	Campaign	WWF SA		L Naudé	Oct-22	Mainstream media	https://www.businesslive.co.za/bd/ opinion/ 2022-10-26-louise-naud-just- transition-finance -should-be-grants-not-loans/
Keynote Speech by Hon. Dr. Nobuhle Nkabane, MP, Deputy Minister of Mineral Resources and Energy at the Southern Africa Oil and Gas Conference (Nkabane -SAOGA conference, 2022)	Gov	DMRE	Nkabane (Deputy Minister)	G Mantashe	Sep-22	Speech	https://www.energy.gov.za/files/me dia /speeches/2022/Keynote-Speech- by-Deputy- Minister-at-the-Southern-Africa-Oil- and- Conference -15092022.pdf
Clueless De Ruyters persistent failures promote the privatization Of ESKOM (NUMSA, 2022)	Union	NUMSA		M Mbodi	Sep-22	Press release	https://numsa.org.za/2022/09/cluel ess-de-ruyters-persistent-failures- promote-the-privatization-of- eskom/
Government must reject fracking proposals to protect regional food security (AgriSA, 2022)	Agricultural organisation	AgriSA	J Rabie	J Rabie	Sep-22	Press release	https://agrisa.co.za/media/governm ent-must-reject-fracking-proposals- to-protect-regional-food-security

Address by the Director General of the Department of Mineral Resources and Energy Mr Jacob Mbele At The DFFE DMRE Joint Oil And Gas Colloquium (Mbele – Oil and Gas Colloquium, 2022)	Gov	DMRE	J Mbele (Director General)	G Mantashe; B Creecy	Jul-22	Speech	https://www.energy.gov.za/files/media /speeches/2022/Address-by-DG-Mbele-at-The-DFFE-DMRE-Joint-Oil-and-Gas-Colloquium-15072022.pdf
A Just Transition Framework (PCC, 2022)	Gov	PCC		PCC	Jul-22	Policy framework	https://www.climatecommission.org.za/just-transition-framework
Climate and Energy Justice Campaign (groundWork, 2022)	Campaign	Groundwork		B Peek	Jul-22	Policy statement	https://groundwork.org.za/the-groundwork-climate-and-energy-justice-campaign/
It all hinges on Renewables (NBI, 2022b)	Business	NBI		J Yawitch	Jul-22	Technical report	https://www.nbi.org.za/report/it-all-hinges-on-renewables/
Keynote Address by President Cyril Ramaphosa at the 2022 Investing in African Mining Indaba (Ramaphosa - Investing in African Mining Indaba, 2022)	Gov	President	C Ramaphosa (President RSA)	C Ramaphosa	May-22	Speech	https://www.gov.za/speeches/president-cyril-ramaphosa-2023-state-nation-address-9-feb-2023-0000 (Accessed: 09 November 2023).
Remarks by The Honourable Minister of Mineral Resources and Energy Mr Gwede Mantashe on The Occasion of The Africa Energy Indaba (Mantashe – Africa Energy Indaba, 2022)	Gov	DMRE	G Mantashe (Minister DMRE)	G Mantashe	Feb-22	Speech	https://www.youtube.com/watch?v=oAQlJKTa0d4&ab_channel=SABCNews

Remarks by the honourable Minister of Mineral Resources and Energy Mr Gwede Mantashe at the National Energy Dialogue (Mantashe – National Energy Dialogue, 2022)	Gov	DMRE	G Mantashe (Minister DMRE)	G Mantashe	Feb-22	Speech	https://www.energy.gov.za/files/media /speeches/2022/Remarks-by-Minister-at-The-National-Energy-Dialogue-25022022.pdf
Remarks by The Honourable Minister of Mineral Resources and Energy Mr Samson Gwede Mantashe on The Occasion of The SONA Debate (Mantashe – SONA debate, 2022)	Gov	DMRE	G Mantashe (Minister DMRE)	G Mantashe	Feb-22	Speech	https://www.gov.za/speeches/minister-gwede-mantashe-debate-state-nation-address-15-feb-2022-0000 (Accessed: 09 November 2023).
The role of gas as a transition fuel in South Africa's path to net-zero (NBI, 2022d)	Business	NBI		J Yawitch	Feb-22	Press release	https://www.nbi.org.za/wp-content/uploads/2022/02/NBI-Press-Release-15-Feb-22-The-role-of-gas-FINAL.pdf
State of the Nation Address (SONA, 2022)	Gov	President	C Ramaphosa (President RSA)	C Ramaphosa	Feb-22	Speech	https://www.gov.za/speeches/president-cyril-ramaphosa-2022-state-nation-address-10-feb-2022-0000 (Accessed: 09 November 2023).
The role of gas in RSA's path to net-zero (NBI, 2022a)	Business	NBI		J Yawitch	Jan-22	Technical report	https://www.nbi.org.za/report/the-role-of-gas-in-south-africas-path-to-net-zero/
Just transition; blueprint for workers (COSATU, 2022)	Union	COSATU		L Mulaisi (COO)	Jan-22	Summary document	https://mediadon.co.za/wp-content/uploads/2022/04/COSATU-

							Just-Transition-Blueprint-Full-version.pdf
Fossil gas: Decarbonisation solution, detour or dead end? (WWF, 2021)	Campaign	WWF SA		L Naudé	Dec-21	Factsheet	https://www.wwf.org.za/?40765/fossil-gas-decarbonisation-solution-detour-or-dead-end
Unions uneasy over South African Just Transition finance (NUM; NUMSA, 2021)	Union	NUM; NUMSA		M Mbodi	Nov-21	Mainstream media	https://www.industriall-union.org/unions-uneasy-over-south-african-just-transition-finance-deal-announced-at-cop26
Climate Change Policy (FEDUSA, 2021)	Union	FEDUSA	J Hugo	J Hugo	Oct-21	Mission statement	http://nteu.org.za/media/1382/fedusa-climate-change-policy-october-2021.pdf
JET factsheet (ESKOM, 21)	Utility	ESKOM	M Rambharos	M Rambharos (retired)	Sep-21	Factsheet	https://www.eskom.co.za/about-eskom/just-energy-transition-jet/
Upstream Petroleum Resource Development Bill (UPRDB, 2021)	Gov	DMRE		G Mantashe	Jun-21	Legal	https://www.parliament.gov.za/storage/app/media/Bills/2021/B13_2021_Upstream_Petroleum_Resources_Development_Bill/B13_2021_Upstream_Petroleum_Resources_Development_Bill.pdf

Down to Zero: the politics of just transition (groundWork, 2019)	Campaign	GroundWor k	D Hallowes; V Munnick	B Peek	Nov-19	Organisation report	https://groundwork.org.za/wp-content/uploads/2022/07/down-to-zero.pdf
Integrated Resource Plan (IRP, 2019)	Gov	DMRE		G Mantashe	Oct-19	Policy document	https://www.energy.gov.za/irp/2019/IRP-2019.pdf

Table 4.2: PCC document information

5. Paper 2: Shale gas estimates in South Africa: the politics of possibility in the national energy dialogue

ABSTRACT

There has been significant interest in South Africa's shale gas reserves since the US Energy Information Administration (EIA) published its 2011 world shale reports, which estimated there to be 485 trillion cubic feet (Tcf) of technically recoverable shale gas in South Africa. This paper seeks to connect shale gas resource estimates to developing concepts in critical resource geographies literature, specifically, the politics of possibility and resource-making, and (un)making framings of shale gas resource estimates, and their associated geo-imaginaries. The research used a mixed methods approach of semi-structured interviews and document analysis to obtain primary data. The data derived from these processes was integrated with existing critical resource geographies research, and applied at a national level, using known examples of resource estimates, as a basis for a qualitative analysis of shale gas resource development in South Africa. It was found the initial EIA estimates set in play a stream of national resource politics and political strategizing, and remain a significant influence on the national energy dialogue to date. This was found to be because of both its continued use by the DMRE, PASA, and the CGS, but also because of the potency of its associated geo-imaginary horizons, and political possibilities. The use of the uncertainty of resource estimates was found to be used as justification for the mobilisation of resources, and these "gestures" were found to feed into politics of possibility.

Keywords: South Africa; shale; imaginaries; politics of possibility; discourse

5.1. Introduction

There is a growing body of critical-resource geography literature exploring the relationship between speculative geo-scientific knowledge and its influence on energy discourse and policy (*e.g.* Cantoni et al., 2018; Kama and Kuchler, 2019; Kuchler and Bridge, 2023). Within this literature it is being proposed that rather than being an impediment, the difficulty of accurately quantifying the subsurface provides an opportunity for policy-makers because it allows flexibility to map a variety of different pathways (*e.g.* socio-economic, geo-political, policy etc.), facilitating the emergence of what Kama and Kuchler (2019) describe as "geo-imaginaries". By presenting geological unknowns as an opportunity, rather than risk, it is possible to generate a narrative of endless possibility, and create a scenario that can only be discredited by extensive, and expensive, geo-investigation, which may be in and of itself a desirable outcome for certain policy-makers or stakeholders. Moreover, employing geo-imaginaries allows future possibility to be brought forward to the present, *e.g.* by generating investment, addressing voter concerns, or establishing a social licence to operate, without necessarily needing to act on policy in the short-term.

Such considerations are relevant in a South African context and in relation to the possibility of future shale gas exploitation. The Republic of South Africa (RSA) is experiencing an ongoing and prolonged energy crisis. It is reliant on ageing coal-powered generators, and on an energy infrastructure that is insufficient to supply demand. This energy shortage results in periodic blackouts, known as "loadshedding", which are having significant socio-economic impact (Umar and Kunda-Wamuwi, 2019) and exacerbate the prevalent energy poverty (Monyai et al., 2023). At the same time, the national energy utility company, Eskom, has been beset by numerous controversies including mismanagement, corruption, and infrastructural sabotage (Carruthers, 2019; Kapstein, 2023). There is nevertheless ongoing work to upgrade and diversify the national energy supply both to meet energy demand and to achieve international climate commitments. To further complicate matters, the African National Congress (ANC) is facing significant political headwinds going into the 2024 elections, potentially facing the loss of its government majority for the first time since the first free elections were held in 1994 (Rapanyane, 2021), with energy security regularly being identified as a major concern of the electorate (Lawrence, 2020).

One potential solution being promoted by the ANC to partially address these challenges is the development of unconventional shale gas reserves. There has been significant interest in RSA's shale gas reserves since the US Energy Information Administration (EIA hereafter) published its 2011 world shale reports, which initially estimated there to be 485 trillion cubic feet (Tcf) of technically recoverable shale gas in RSA.[41] Although the EIA revised these estimates down to 390 Tcf in 2013, this would (if realised) present the possibility of a significant new energy resource for the country. Consequently, the potential benefit of exploiting these resources has become a focal point for numerous socio-economic and geo-political projections (Auping et al., 2016; Wait and Rossouw, 2014) and much contested political debate.

Since the EIA reports were published, there has been no commercial production of unconventional gas in RSA, but shale gas has nevertheless remained a constant feature within the national energy landscape; a subject of public debate, of scientific research, and of legal action. It has also become the focus of endless speculation, because underpinning the socio-economic and geo-political promises associated with a vast untapped energy source, there is a hugely diverse range of speculative resource estimates. Despite the limited data available to instruct resource estimates, there has nonetheless emerged three distinct and authoritative volumetric ranges within the national shale gas discourse. These are: 1: the initial EIA estimates of 485 and 390 Tcf; 2: estimates from the de Kock et al. (2017) study at the much lower level of 13 Tcf (within a range of 13 – 49 Tcf); and, 3: Petroleum Agency South Africa's (PASA) revised (2018 – present) estimates of 209 Tcf. Although each of these figures are necessarily estimates, and are acknowledged as such by their proponents, they are nonetheless significant for the formulation of energy policy, for investment strategies, and for the shaping of the national energy dialogue.

This paper explores how these three volumetric estimates of shale gas reserves have been used in a political context, both in capturing the politics of possibility (Kuchler and Bridge, 2023), and as part of broader political strategy (Kuchler, 2017). It also explores how the estimates have been integrated into geo-imaginary horizons to shape energy policy and energy discourse in RSA. It will examine why a range of materially different shale gas estimates have come to dominate the shale debate in RSA, who is employing these numbers,

[41] Technically recoverable reserves are estimates of reserves that can be recovered using existing technology and current industry practices, irrespective of economic or accessibility considerations. Recoverable reserve estimates are costed reserves that fluctuate according to external influences, *e.g.* global resource prices, government regulations, and operating methods. Proven reserves are considered to have at least a 90% probability rate of being recoverable, unproved reserves are deemed not recoverable due to economic factors or regulation. With this in mind, probable reserves refer to reserves that are considered to have an estimated 50% likelihood of being recoverable and possible reserves with only a 10% probability of recovery (USGS, 2023). This research is focussing on technically recoverable estimates, of unproven reserves.

and what their significance is when viewed through a critical resource geography lens. This case study will add to the body of research on critical resource geographies (Bakker and Bridge, 2006; Bridge, 2010; Huber, 2016) and provide a distinctive insight into the RSA shale gas debate and its energy policy landscape. Specifically, this research takes a mixed methods approach, triangulating document analysis, media discourse analysis and semi-structured interviews, to examine: 1: how and when the resource estimates have been employed by the key gatekeepers of RSA's geo-scientific knowledge, and in mainstream media (*i.e.* conventional, well-known news outlets such as newspapers and television channels); 2: how the estimates have been integrated into the geo-imaginary horizons: 3; how the estimates have influenced political policy and strategy.

The paper begins with a brief literature review, outlining the conceptual framework for the research, which expands on themes outlined by Kuchler (2017), Kuchler and Bridge (2023), and Cantoni et al. (2018) namely: (i) resource-making and geo-imaginaries, (ii) speculation and socio-technical promises, (iii) the politics of possibility. This is followed by a methods section outlining the applied methods, and the overall methodology of the wider research project that have informed this research. Section 4 comprises a combined results and discussion section. This includes a critical overview of shale gas resource development in the RSA context, an outline of the relevant shale gas resource estimates and stakeholders, and a critical discussion covering how resource estimates are integrated with the framings and counter framing of shale gas in the RSA energy discourse.

5.2. Critical resource geographies

Recent developments in critical-resource geography have provided a novel way of approaching studies into the subsurface. Kinchy et al. (2018) propose that, contrary to popular belief, the underground, and the resources therein, are not fixed entities, existing *a priori*, waiting to be discovered or extracted, but are rather entities that emerge from a combination of economic, techno-scientific, cultural, and political processes and practices. Certain aspects of this appraisal seem on the face of it to be relatively straightforward. These include technical innovations which permit the exploitation of previously difficult to extract resources (*e.g.* the development of high-volume hydraulic fracturing techniques (HVHF hereafter), that allow the extraction of tight oil and gas), and the economic reality of resource extraction being subject to fluctuations in global prices. However, entwined within the techno-scientific and economic realities of resource extraction, there are a multitude of more nuanced forces at play, often situated within localised socio-economic, socio-political, and energy landscapes (Reed, 2002;

Zabré et al., 2021). For example, Swann-Quinn (2018) explores the role of mining in post-Soviet Georgia, demonstrating how concepts such as ethnicity, land-use, homeland, and environmental degradation are being incorporated into “popular geopolitical scripts” (Swan-Quinn, 2018 p. 122), and Bugden et al. (2017) examine how lived experience of resource extraction influences perceptions of new forms of energy development. This research, however, is focussing on potential resources, as opposed to existing or historical resource production, which inherently introduces a suite of unknowns. Because a resource is as yet to be effectively established and made visible and materially knowable, technical and scientific uncertainties are introduced, as Abreau (2012) puts it:

> “We are dealing with a scientific matter that is complicated because it happens out of our sight. We are dealing with a geological matter that is found in the subsoil while we are here, above ground” (Abreau, 2015 p. 1)[42]

Abreau expands on this by highlighting that because a potential (in this instance petroleum) resource is theoretical until it is successfully extracted, there is an intermediary process needed between these stages, that of imagination:

> “We are dealing with petroleum in an imagined form. And people keep imagining, predicting, and hoping that what we hold in our minds or in our imagination or in the results of the studies we have done is true” (Abreau, 2015 p. 1)

Given that a resource is unknown, it is proposed that for it to be rendered *knowable*, it must first be subject to some external scrutiny, *e.g.* economic, technical, or spatial, that transforms something from a mineral to a resource, that is, no longer merely part of the subsurface, but something worthy of exploitation (Himley, 2021; Kama, 2020), a process becoming established as “resource-making” (Himley, 2021; Kama, 2020; Kuchler and Bridge, 2023). Kuchler and Bridge (2023) outline three tenets of the resource-making process which are particularly relevant to contemporary studies of shale gas exploitation in RSA: these are geo-imaginaries, speculation, and resonance.

5.2.1. Resource-making and geo-imaginaries

First, it is proposed that the “hidden, indeterminate, heterogenous and immense volumetric character” (Kuchler and Bridge, 2023 p. 3) of the subsurface provides a fertile space for

[42] Translation provided by Weszkalnys, 2015.

speculation of future potential and / or productivity. That this potential may not be realised is an inherent risk in mineral exploration, so to encourage empirical activities, they argue, it is necessary to create geo-imaginaries to mitigate this uncertainty, and reframe it as possibility. How these geo-imaginaries manifest is necessarily a product of the local energy landscapes, (*e.g.* the exaggeration of prospective investment returns, the promise of increased energy security, or the potential for socio-economic development (Cotton, 2016; Heinberg, 2014; Jackson et al., 2014), but their origins are predominantly derived from either incomplete or imperfect empirical data, or analogy (Kneas, 2018; Kuchler and Bridge, 2023; Weszkalnys, 2015). Furthermore, to maintain the discourse that is created via geo-imaginaries, these imperfect data or analogies, and their associated promises, require sustained exposure to their intended audience (see *e.g.* Fry and Murphy, 2021). How this data is made and conveyed is again locally-specific, but, for example, potential gas estimates would typically include geo-spatial analyses, numerical assessments or volumetric appraisals (King, 2012; Kuchler, 2017), alongside analogous realised resource extraction examples. So, resources are presented as estimates which can then acquire powerful socio-economic and socio-political authority, promoting future expectations, without the need to necessarily verify their assessments or realise their potential.

5.2.2. Speculation and technoscientific promises

The power of resource speculation is derived from the multiple possible pathways, and their related opportunities, that can be promoted by different actors, and applied to many social, political, or economic scenarios (Nyberg et al., 2017; Szolucha, 2021), by which anticipatory values (social, economic etc.) become actionable in the present, in the form of technoscientific promises (Cantoni et al., 2018; Kuchler and Bridge, 2023; Szolucha, 2021). Examples of technoscientific promises based on speculation are evident within the shale gas discourse globally, and have occurred since the shale revolution began in the early 2000s (Cantoni et al., 2018; Kama, 2013; Stevens, 2012). The promises of shale have been framed in multiple ways. As of economic benefit (both in socio-economic and / or investment terms (Bilgili et al., 2020; Kinnaman, 2011)): as a means of increasing energy security (either domestically, or in a geo-political context (Bellani et al., 2021)), or, environmentally, as a means of reducing carbon emissions and meeting international climate commitments (the so-called bridge-fuel or transition-fuel approach to shale gas (Delborne et al., 2020; Jenner and Lamadrid, 2013)). Given the scope of these technoscientific promises, it is not surprising that they remain prominent in many national energy landscapes, particularly where large potential resources were identified in the early days of the shale revolution. Cantoni et al. (2018 p. 538) identify how shale gas related “horizons of expectation[s]” emerged in France, Germany, and Poland, and how the various framings were manipulated to appeal to differing energy and socio-economic regimes. They found that the Polish government focussed on the freedom from foreign (particularly Russian) influence, and on job creation as the dominant framings. In Germany, by contrast, where solid fuels still make up a significant part of the energy mix (Kibria et al., 2019), the bridge-fuel framing was the one predominantly employed. Similar efforts adopting a variety of methodological approaches to evaluate the framing of shale gas discourse have also been undertaken, including those focussing on public perceptions (*e.g.* Cotton, 2015; Szolucha, 2018), and studies that analyse particular aspects of the public discourse (*e.g.* Lis and Stankiewicz, 2016; Williams and Sovacool, 2019).

5.2.3. The politics of possibility

Kuchler and Bridge (2023) argue geo-imaginaries have the potential to “spillover” between domains (*e.g.* from epistemic to market, or economic to political), and as such the *value* of the resource is changeable, and not inherent to its physical characteristics. It is therefore proposed that the geo-imaginaries and their outcomes are more than merely correlative (*e.g.* exaggerating resource potential to increase investment), the speculation can become a mode of governance, described by Kuchler (2017) as *governmentality*. It is argued that speculation can manifest as the “politics of possibility” (Kuchler and Bridge, 2023 p. 4), where uncertainty becomes the driving force, allowing political actors to frame decisions as *to be determined*, or as Szolucha (2023 p. 578) describes, the “contradictory temporalities” of resource extraction processes, rendering futures actionable in the present. It is argued that these possibilities can become performative, enabling myriad socio-political potential, for example by awarding tenders, creating exploration zones, dividing land into resource plays (Kuchler and Bridge, 2023; Weszkalnys, 2015). Weszkalnys (2015) describes this type of activity as “gestural” and shows that the uncertainty and subsequent political gain can be maintained over a sustained period of time by enacting these gestures without the necessity for any tangible commercial success:

> “Instruments that aim to facilitate petroleum production—such as contracts, exploration zones, and test wells—thus become gestures of resource potentiality without compelling a predetermined outcome. They give shape to a dispersed matter whose existence has continued to be doubted” (Weszkalnys, 2015)

In this scenario, it is argued that by sustaining activity of some form numerous socio- political and economic ends can be addressed, such as generating capital investment, keeping state resources mobilised, or addressing voter concerns about energy security (Fry and Murphy; 2021; Kuchler and Bridge, 2023: Weszkalnys, 2015).

The concepts outlined in this section collectively provide a productive critical framework to understand speculation and geo-scientific estimation beyond a quantitative and economic lens, and allow a more comprehensive assessment of the processes and products of geo-scientific knowledge, which this research will apply to the shale discourse in RSA.

5.3. Methods

This research is based on a mixed methods approach, using document analysis, media analysis and semi-structured interviews with stakeholders, to explore the different ways in which sets of shale gas estimates have become established and entered into the politics of possibility in the RSA energy landscape.

First, a document analysis was carried out to establish what estimates the gatekeepers of the national geoscientific knowledge were providing, together with any qualifications associated with these estimates, and how, if at all, the estimates have evolved over time. This involved searching the publicly available archives of the DMRE, PASA, and the CGS to identify where estimates have been used. This preliminary analysis provides the factual underpinning of the qualitative aspect of the research, that is, where (*i.e.* document type) resource estimate(s), are used by gatekeepers in the public domain. It should be noted that the archived data from these organisations is not comprehensive, and annual reports of different types (*e.g.* financial statements, integrated annual reports) are in many instances missing, or inconsistently published. The analysis is therefore limited to available resources.

Second, the research identified instances of the resource estimates provided by the gatekeepers, and those by de Kock et al. (2017) in the media. This was done by carrying out a series of internet searches of media publications between 2017 and 2023 inclusive, applying a Boolean search method to include the keywords: South Africa, Shale gas, and Tcf, or variations thereof (*e.g.* RSA, SA, trillion cubic feet, shale). Only media sources that contained direct references to specific resource estimates were included in the data analysis (the analysis of gatekeeper documents includes material without specific resource estimates). The results were filtered to exclude non-media sources (*e.g.* private company technical reports). The date range of the preliminary search began at 2011 (*i.e.* the date of the initial EIA report), but 2011-2016 were excluded in the final data analysis owing to the reduced availability of archived data in older records. Data sources and relevant information are shown in appendix i.

Third, primary data was collected through a series of expert interviews and by attendance of numerous stakeholder engagement meetings about RSA's shale gas development. 16 interviews (and several follow-up interviews and related correspondence with participants) were conducted between 2018 and 2023, both in-person and online (appendix ii). Participants were identified for their expertise in the various fields associated with UOG extraction. The scope of the interviews was broad, as it formed the basis of a larger body of research investigating UOG and the water-energy nexus in RSA, and as a result, included a diverse range of expertise, including geology, hydrogeology, UOG, energy systems, governance, and policy development, Participants were largely based in RSA, although there was some international representation, notably from the US, to get the perspective of those knowledgeable on a more developed UOG landscape. In addition, several stakeholder engagement meetings were attended, including events organised by DWS (event in 2021), Council for Geoscience (event in 2022), South African Oil and Gas Alliance (SAOGA) event in 2021), as well as visiting researchers working on shale gas development at the University of the Free State (UFS). All interviews were recorded and transcribed in full, and events were recorded where permitted and if practicable. The data transcripts were then thematically coded for qualitative analysis using F4 Transcript software. The thematic codes employed reflected the nature of this research, categorising responses according to subject (*e.g.* energy security, socio-economic), with further sub-categorisation (*e.g.* geo-political, self-sufficiency, private investment, concessions).

There is a historical timeline of unconventional oil and gas extraction, and related studies (appendix iii), that will be referred to during the discussion. This contains information relevant to the research, but is omitted from the main body of text for stylistic purposes.

The combined results and discussion section includes a qualitative analysis of the findings of the combined data analyses, specifically identifying instances where the resource estimates have been applied in ways that can be reasonably interpreted as relevant to the critical resource geographies literature as outlined in section 2. Specifically, addressing how the use of shale resource estimates in RSA have been applied by stakeholders to: create (or dismantle) geo-imaginaries; support (or reject) technoscientific promises; are framed within the politics of possibility; and, the potential motivations of the positions adopted by different stakeholders. The qualitative analysis is informed by the themes outlined in section 2, and the findings of the interview and stakeholder engagement processes. The results include direct quotes from both the combined data analyses and primary interview data where applicable.

5.4. Discussion

5.4.1. The beginning of shale gas resources and the shale debate in South Africa

Following the early successes of shale gas production in the US, the US Energy Information Administration produced in 2011 a shale gas resource assessment of 14 regions outside the United States (EIA, 2011), which included Southern Africa (specifically RSA). The data on which this assessment was based, was compiled using existing public geological information and reservoir properties in technical and scientific literature, publicly available company data, and augmented with proprietary prior shale resource data from Advanced Resources International (ARI) (EIA, 2013b). The methodological approach was relatively simple, involving: 1: conducting preliminary geologic and reservoir characterisation; 2: establishing areal extent of formations; 3: defining the area; 4: estimating risked shale gas in-place[43]; 5: calculating technically recoverable gas reserves (see EIA, 2013b for detailed methodological approach). The data applied to their RSA model was acknowledged by the EIA to be based on "limited preliminary data" (EIA, 2011 p X-2), but from these preliminary assessments it was concluded there were technically recoverable shale gas resources of 485 Tcf (EIA, 2011).

In 2013, the EIA replicated these assessments, using the same methodological approach, but with further data that had emerged since the original study. This resulted in the aerial extent of the RSA basin being reduced owing to known igneous intrusions covering large parts of the initial area, which would likely impact the quality of the shale gas resources (EIA, 2013). The 2013 assessment concluded RSA had technically recoverable shale gas resources of 390 Tcf (EIA, 2013). These reports identified RSA as a major source of potential shale reserves, ranking it initially as 4th and then with the revised figure as 8th (see figure 1) in the international hierarchy the regional assessments generated. This was in itself an important geo-imaginary of energy resources waiting to be exploited between competing resource-endowed nations, suggesting that RSA could (and should) become a significant player.

[43] "The risked gas in-place estimate is derived by first estimating the amount of 'gas in-place' resource for a prospective area within the basin, and then de-rating that gas in-place by factors that, in the consultant's expert judgement, account for the current level of knowledge of the resource and the capability of the technology to eventually tap into the resource. The resulting estimate is referred to as the risked gas in-place" (EIA, 2011 p. 6)

Rank	Country	Shale gas (trillion cubic feet)	
1	China	1,115	
2	Argentina	802	
3	Algeria	707	
4	U.S.[1]	665	(1,161)
5	Canada	573	
6	Mexico	545	
7	Australia	437	
8	South Africa	390	
9	Russia	285	
10	Brazil	245	
	World Total	**7,299**	(7,795)

[1] EIA estimates used for ranking order. ARI estimates in parentheses.

Figure 5.1: EIA table of technically recoverable shale gas resources (EIA, 2013)

The known presence of dolerite intrusions, underpinning the EAI downgrading of resource estimates were identified in by interviewees as an area of considerable geoscientific disagreement, with it being suggested they are more significant than the EIA are calculating with potentially major implications for the scale of gas resource:

> “At the time of the breakup of Gondwanaland we got a lot of intrusions of lava which either formed basaltic layers, or formed dolerite intrusions, and they cooked out the hydrocarbon, so what's left is not very much, and it is basically a rather poor energy resource because the best volatiles have been lost, it's over mature” (participant 5)

> “One school of thought is that this dolerite has burned off all the gas, and there's virtually nothing left” (participant 10)

Further, from a technical perspective. It is argued that the presence of dolerite intrusions is underestimated in the EIA’s technically recoverable equation:

> “Because of the fragmentation of the resource into quite small compartments, the horizontal drilling doesn’t work very well, you actually have to drill a long way and then fracture, but you can't do that in these dolerite compartments, because as you drill along, you might get to a dyke […] if the shale continues on the other side of the dyke,

> it's often displaced, you can't go through in a straight line, you can't, and you have to go find it again, and that makes the whole thing uneconomic" (participant 5)

The initial EIA reports are arguably a form of global resource-making, in which limited existing geological information was reinterpreted through their specific technoscientific lens. The global impact of these EIA reports has been profound, generating debate worldwide (McGlade et al., 2013; Melikoglu, 2014) and as shown, immediately set in motion debate between local scientists and policy-makers. But particularly relevant to this research, is that it established these speculative estimates as a persistent feature in RSA's energy dialogue.

5.4.2. Gatekeepers, de Kock et al. (2017), and PASA estimates

The EIA estimates provided an internationally authoritative 'making visible' of shale gas potential in RSA, but key institutions within RSA then had to take responsibility for them, acting as gatekeepers for further generation and institutionalisation of relevant geoscientific knowledge and its relations with wider energy discourse. There are three primary state-owned gatekeepers of geoscientific knowledge in RSA (see Table 1): 1: the Department of Mineral Resources and Energy (DMRE); 2: the Council for Geoscience (CGS); 3: the Petroleum Agency South Africa (PASA). Although there is some private-sector involvement in RSA's national shale landscape, existing data (*i.e.* core samples) and current invasive exploratory work (the Karoo Deep Drilling Project) are all held and overseen by state agencies. Both the CGS and PASA are overseen by the DMRE giving the Ministry some degree of primacy and overarching influence across this institutional structure.

Gatekeeper	Overview	Key people
Department of Mineral Resources and Energy (DMRE)	Ministerial department responsible for overseeing the mining and energy sectors. The DMRE is the overarching department responsible for energy policy-making and policy implementation, and since the amalgamation of the mineral resources and energy portfolios in 2019, is designed to be a key driver in implementing the National Development Plan (NDP) objectives of economic growth through sustainable development of the national mineral and energy resource sectors (DMRE, 2023)	Mr. Gwede Mantashe, Minister of Mineral Resources; Dr Nobuhle Pamela Nkabane Deputy Minister of Mineral Resources
Council for Geoscience (CGS)	The CGS was established to promote the search for, and exploitation of any mineral in South Africa. It is mandated to generate, compile, curate and publish world-class geoscience knowledge products, provide geoscience-related services to the South African public and industry, and render advisory services related to geohazards and geo-environmental pollution. The Karoo Deep Drilling Project is being conducted by the CGS. CGS is overseen by the DMRE	Mr. Mosa Mabuza: Chief Executive Officer
Petroleum agency South Africa (PASA)	To promote, facilitate and regulate exploration and sustainable development of oil and gas contributing to energy security in South Africa. Overseen by the DMRE	Dr. T. Mokoka, Acting Chief Executive Officer; Mr. B. Sayidini, Chief Operations Officer: Petroleum Resource Evaluation and Operations Management; Dr. Phindile Masangane, former CEO

Table 5.1: RSA gatekeepers of geo-scientific knowledge, their roles and responsibilities

The most accessible public-facing information sources provided by the gatekeepers (*i.e.* DMRE shale gas webpage, and the GGS Karoo Deep Drilling Project (KDDP) webpage, and PASA onshore resources webpage), all contain reference to the EIA estimates. Both the DMRE and the CGS provided the 2011 and 2013 EIA estimates as their current estimation:

> "South Africa has an estimate of 390 trillion cubic feet (Tcf) of technically recoverable natural gas that can be extracted from shale and this is embedded in the Karoo Basin" (DMREa, Shale Gas)

> "South Africa has an estimated 485 trillion ft3 […] and 390 trillion ft3 […] of technically recoverable natural gas from shale reservoirs" (CGSa, KDDP)

PASA also uses the 2011 EIA estimate, but as the upper end of their very wide estimate range, although PASA are now actively promoting a revised figure of ≈ 205 Tcf:

> "Technically recoverable gas-in-place scenarios suggests volumes range between 30 Tcf to 485 Tcf" (PASAa, Onshore Karoo Basins)

2017 saw the publication of the first direct measurements of the actual gas contents of southern Karoo basin shales by de Kock et al. (2017), which concluded:

> "Very likely the most realistic resource estimates for the Karoo basin are between 13–49 Tcf, with the lower estimate perhaps being the most realistic given the sparsity of data" (de Kock et al., 2017 p. 11)

From 2018, and after the publication of the de Kock research, PASA began publishing revised internal estimates of ≈205 Tcf (PASA's publications have at various times shown 200 Tcf (Masangane, 2023), 205 Tcf (Adams, 2019), and 209 Tcf (Sayidini, 2022).

How this revised estimate was arrived at is not at all clear, but publicly available information suggests the EIA estimates were downgraded according to the results of a refined basin model which further identified the location of known dolerite intrusions. The PASA estimate therefore appears to be the product of the same methodological approach as used by the EIA, and the ≈205 estimate is simply the result of a smaller geographical area being used in the equation. This re-evaluation of aerial extent was what led the EIA to downgrade their 2011 estimate of 485 Tcf to the 2013 estimate of 390 Tcf. The lack of clarity here became apparent when attempting to obtain the PASA data underpinning their new resource estimate. The data would only be supplied after the payment of a substantial fee (an initial request of USD$1000), and there was a requirement to sign legally binding data protection contracts before it would be supplied.[44] But given that these estimates were produced before any testing conducted by the CGS as part of the KDDP, it is therefore assumed that these estimates are based on a narrower delineation of the proposed "sweet spot".[45]

[44] This research is part of a larger PhD research project, which will be reviewed both internally and externally, so and as such all data used would need to be available to as yet undetermined 3rd parties, contrary to PASA's contractual requirements.

[45] The "sweet spot" refers to a target location or area within a play or a reservoir that represents the best production or potential production. In the Karro this considers the areas of known dolerite

5.4.3. The politics of possibility: political strategy

Given the high estimates provided by the EIA for RSA shale gas reserves, and the economic impact indigenous gas had in the US (Kinnaman, 2011), it is unsurprising that there was early interest from multiple stakeholders both inside and outside RSA. Further, that these early estimates triggered speculation on the potential socio-economic, developmental, and energy security benefits such reserves could provide (Andreasson, 2018) is equally unsurprising. And whether intentionally or not, the RSA government set out to make use of this speculation very early on in the debate, in a way that has changed little in the following decade (Andreasson, 2018).

5.4.3.1. Sustaining speculation

That both the CGS and the DMRE continue to use the EIA estimates means that high-end, and arguably outdated estimates, continue to filter into the media discourse. This is relevant from a critical resource geographies perspective, as they remain in circulation even when the purpose of a publication is to outline different (and potentially more informed) estimates, leading to yet more epistemic uncertainty Kuchler and Bridge, 2023). This has happened in both instances when a revised estimate has been promoted in RSA, *i.e.* the de Kock et al. (2017) research, and the revised PASA estimate. In these instances, the EIA estimates typically comprise the upper-end of a range of estimates (see 2017a; 2017b; 2017c regarding de Kock et al. (2017); and 2023b; 2023c; 2023e regarding PASA), for example:

> "The current estimates of the Petroleum Agency of South Africa [estimates] resources of some 205 Tcf, with different surveys giving ranges of between 30 Tcf to as much as 485 Tcf" (Biz News, 2023l)

The fact that many of these media sources directly cite the gatekeepers' use of the EIA 2011 and 2013 estimates, as well as the gatekeepers' continued promotion of these estimates (notwithstanding that their own (*i.e.* PASA's) estimates) are considerably lower, suggests they are actively intensifying uncertainty. When viewed through a critical resource geographies lens, it seems likely this amplification of uncertainty is designed to instil speculative geo-imaginaries in the energy discourse, that can be manipulated for political ends (Cantoni et al., 2018; Kuchler, 2017; Kuhler and Bridge, 2023).

intrusions, and their potential to have reduced the quality or quantity of shale gas reserves (de Kock et al., 2017: SLB, 2024).

5.4.3.2. Governmentality and action

Kuchler (2017) uses Foucault's (1982) concept of *governmentality* as an epistemic lens through which to explore the political exploitation of imaginaries and uncertainty, and by employing a "micro-political analytic[al]" lens (Lövbrand and Stripple, 2015 p. 95), it is possible to critically engage with political strategies, and to unpick their potential motivations and objectives (Kuchler, 2017).

Using this approach, it emerges that the speculative resource estimates being promoted by the gatekeepers can serve both a political and an economic function, and justify a continued mobilisation of resources. PASA's most recent available financial statements (PASAc, Integrated Annual Report (IAR)) identify that their shale gas project constituted 17% of the agency's total expenditure, and was at least 3 times that of all its other expenses excluding employee costs (PASAc IAR, p. 37), and 28% of its revenue split (PASAc IAR, p. 38). This indicates that the agency could have a particular interest in maintaining the resource potential of shale, which raises questions about the potential of an intra-governmental stratagem in which the agency and the government are both reliant on speculative estimates to meet their particular requirements: the agency to maintain their revenue, and the DMRE to pursue their politics of possibility. For example, in statements such as these by PASA's Chairman in the IAR, the agency appears to be acting as resource-makers on behalf of the DMRE, thus providing the Ministry with plausible deniability for its policies, and justifying their own resources:

> "The regional basin and petroleum systems assessment study of the Karoo is now completed, and it is encouraging that a new sweet spot for the occurrence of oil and gas has been identified. The research findings now indicate that volcanic activity in the Karoo might not have had the disastrous effects on oil and gas systems as originally thought" (PASAc IAR, p. 5).

This political-institutional connection was identified in the interview process, where it was suggested PASA are actually under pressure to coordinate with government political strategy:

> "Part of their [PASA's] responsibility is to promote exploitation of extraction, so that's part of their mandate, but I think the biggest pressure that they have is coming from the ANC politics" (participant 13)

5.4.3.3. Governmentality and resource-(re)making

The continued use of high-end estimates may also serve a practical political purpose. According to Foucault (1993 p. 93), governmentality involves the imagining of futures as a "complex strategic situation", and one in which actions predicate further action (Kuchler, 2017; Miller and Rose, 2008). When this premise is applied to the South African shale gas resource situation, certain factors emerge as significant. The trajectory of shale gas resource development in RSA has been erratic. The initial interest in the shale reserves and their development led to Shell submitting an exploration licence application in 2010, which were subsequently withdrawn in 2018 (see appendix iii.3;iii.20). This period coincided with President Zuma's turbulent administration, and it was argued by participants in this research, that these two factors are connected:

> "[Shell] have now withdrawn from the shale gas exploration in South Africa completely, I think they have simply thrown up their hands and said, "in this sort of toxic environment, there's no way we can do this, and we're simply going to withdraw" (participant 12)

> "When they saw that government is fumbling around and, you know, they're being taken to court, and the regulations are a shambles and whatever, they started withdrawing" (participant 1)

That the ANC have expressed their preference for shale gas resource development (see *e.g.* Integrated Resource Plan, DMRE, 2019) could suggest that the gatekeepers continued use of high-end estimates, and the institutional alignment with these estimates, is part of a broader political strategy. Following Foucault's (1983 p. 220) "actions upon actions" governmentality premise, it is suggested the gatekeepers' "actions" (*i.e.* speculation, investment, and institutional alignment) are a means of addressing the identified problems of the past, and signifying to potential stakeholders that the national shale gas *reserves* are once again *resources*.

5.4.3.4. Speculative estimates as a political win-win

It appears that an element of PASA's using their refined estimates as a means of establishing high expectations, which can later be downgraded and still be seen as a success. This is achieved by making comparisons (Pollet et al., 2015) with RSA's historical and current gas use, and outlining what much lower resources, if realised, could potentially achieve, particularly regarding energy security:

> "Mossgas, which produced 46-000 barrels per day and was in operation for 28 years, was built on the basis of a source of 1.5 Tcf" (Noah (CEF), 2023c)

This position was explicitly expressed by PASA's (then) CEO Dr Masangane in her interview on BizNews (2023k), in which she described the speculation of resource estimates as a "red herring". Her remarks implied that the high-end resource estimates are irrelevant given the potential value of much lower values:

> "For me the debate, whether it's 390 Tcf, 200 Tcf, 13 Tcf, is a red herring , what would 13 Tcf do for this country? Are you aware, that as a country the value we have from Sasol is on the back of 3 Tcf from Mozambique? So, 13 Tcf in the karoo can create two times Sasol, so let's say we are wrong as an agency and the number is not 200 Tcf and the person saying 13 is correct…" (Masangane (PASA), 2023k)

Such comments do nothing to clarify the opaque picture of the different applications of resource estimates in RSA, but they do indicate that PASA realise that their estimates may in time prove to be overstated: but the purpose of statements in which the expectations are moderated is not for the re-evaluation of policy, but as justification for resource mobilisation, and for creating a political narrative that suggests pursuing resource extraction is a win-win scenario.

5.4.3.5. Resource estimates and narrative control

There also appears to be a deliberate effort by gatekeepers to control and coordinate the national energy narrative and the framing of speculative resource estimates. Evidence for this is found in PASA's Targeted Stakeholder Engagement Drive (PASAb, Seismic request for proposals):

> "PASA wishes to engage the services of a well-versed service provider in delivering succinct acritical messages to the media and other key stakeholders, which would ultimately expedite the mandate of PASA as an enabler in the much-needed sustainable development of an indigenous oil and gas industry in South Africa" (PASAb, Seismic request for proposals)

That PASA have identified the need to establish a coherent indigenous oil and gas message is instructive. It suggests they recognise that the current narrative is misaligned with their preferred framing of the national oil and gas industry, and wish to realign it to reflect their socio-technical position. The above quote indicates that these positions are that oil and gas development is both sustainable and necessary: type of reframing described by Renner and Giampietro (2020) as socio-technical discourse story-telling.

Secondly, that the gatekeepers have not incorporated the de Kock et al. (2017) estimates into their socio-technical narrative is also informative. Given PASA's explicit acknowledgement of the value of much lower estimates than their own, it would seem that by integrating these figures, they could establish a more robust empirical basis for shale gas resource development. Very little evidence, however, was found of the gatekeepers acknowledging this report.[46] It was suggested by one interview participant that this is because there is a governmental mistrust of external input in matters that may influence policy:

> "Their [the ANC] natural instinct is not to hold open processes, it is to hold the kind of process where they control information, and determine who does the studies" (participant 13)

If this position is viewed through a critical resource geographies lens, it could be inferred that by incorporating these estimates, it would limit their geo-imaginary horizons. This is particularly relevant given the most extensive shale gas development research to date in RSA, the 2016 strategic environmental assessment of shale gas in the Karoo (SGDCK hereafter), used a three scenario approach in its assessment: these were: scenario 1: exploration only (no gas found); scenario 2: small gas (economically viable discovery of ≈5 Tcf); 3: big gas (economically viable discovery of ≈20 Tcf). These assessments included associated socio-economic assessments, which if adopted by the gatekeepers would confine their geo-imaginaries within these findings. This fact was identified in the discourse analysis, and employed by stakeholders wishing to prevent shale gas resource development:

> "Even if 30 Tcf were found, this would translate into less than 2,600 direct jobs, with only 15% - 35% of these jobs available to Karoo residents" (Daily Maverick, 2017c)

[46] This research found no governmental acknowledgement of the de Kock et al. (2017) research in the media, and only referenced as a footnote in one governmental report published in 2022 by the Department of Science and Innovation, in which the locations of the research was used to question the predictive potential of the research findings.

5.4.4. Uncertainty in action

The speculative resource estimates used by the gatekeepers all had one specific caveat attached to their public-facing estimate sources, although with slightly different framings. This is that the precise resource potential is inconclusive and therefore it is *necessary* to conduct further work to further establish their value, so it might well be that this approach to resource-making serves a socio-political purpose, insofar as the exploration is not just a means to an end (*i.e.* resource exploitation), but also serve as a "gesture" of resource potentiality (Kuchler and Bridge, 2023 p. 3; Weszkalnys, 2015). This is therefore a political narrative that uses speculation and uncertainty to indicate possibility, but also to justify actions that are in-line with the gatekeepers' preferred policy pathways. However, embedded in these justifications are also framings that reflect various aspects of the broader shale debate in RSA. For example, The DMRE the use economic and environmental framings to validate their position:

> "Detailed research studies are very crucial for the country because shale gas exploration in South Africa could be facing two major unknown geological questions [i] the amount of economically recoverable gas trapped in the Karoo formations [ii] the geo-environmental problems linked to the nature and the structure of the rock, the groundwater migration and the micro-seismicity" (DMREa)

Similarly, PASA supply economic and ecological justification (Onshore Karoo Basins, PASAa), whereas the CGS provide scientific knowledge-gaps as the reason to act, a likelihood supported by de Kock et al. (2017):

> "Quantitative scientifically-based conclusions cannot be drawn […] with the currently available information. A vertical deep research borehole is therefore deemed necessary" (Research Initiative for KDDP, CGSb)

> "It is acknowledged that the drill cores we investigated fall outside of currently identified "sweet spots" and these areas should be targets for further scientific drilling projects" (de Kock et al., 2017 p. 1)

But the gestural nature of these positions was identified in the interview process. It was noted that despite indications that more research is required, and that funding has been allocated (see section 5.4.3.2), outcomes do not appear to be the primary objective:

> "The Council for Geoscience […] are slowly starting to get some sort of idea what's going on, but at this stage there's no real drive to say, 'OK, let's push some energy into this'" (participant 4)

Kuchler and Bridge (2023) argue that such gestural approach to resource-making enables what is only a possibility to survive, even when faced with contradictory materialities, social or geoscientific, and are part of the "anticipatory rhythms" of resource-making (Kuchler and Bridge, 2023; Szolucha, 2023, p. 13). Both social and geoscientific contradictory realities are present in RSA, with no meaningful shale resources proven, and an ongoing resistance from a variety of stakeholder against shale gas resource development (appendix iii.5). So gestural actions may prove politically beneficial in the short term, even if no resources materialise, a plurality described by Kuchler and Bridge (2023 p. 10) as "contradictory temporalities": these were found to be evident in the interview process. When Participant 12 was asked "why do you think there has been a reluctance to act on those recommendations [monitoring activities]?", the answer was, "Because it's such a distant prospect" (participant 12).

5.4.5. Geo-imaginaries and speculation

As discussed in section 2, resource-making practices and their consequent geo-imaginaries utilise the sustained exposure of incomplete or imperfect data as a tool to reinforce their intended message (Kneas, 2018; Kuchler and Bridge, 2023; Weszkalnys, 2015). By this analysis, the revised estimates from PASA, which appear to be simply a repackaged version of the EIA estimates, seem to be designed to accommodate the narrative that emerged after the de Kock research. Rather than resolutely sticking with the very large initial volumes of gas indicated as a viable resource by the EIA estimates, the new figure of 205 Tcf appeared to integrate some greater realism into PASA expert position, but without fundamentally undermining the speculative politics of possibility and geo-imaginaries at scale that were already in play. There was evidence of the speculative resource estimates being employed alongside both energy security and socio-economic geo-imaginaries, for example:

> "Scenarios suggest volumes range between 30 Tcf to 485 Tcf Shale gas […] exploration could possibly create many jobs in the outlying areas of the rural Karoo" (PASAa, Onshore Karoo Basins)

There was also evidence that these geo-imaginaries had filtered into the wider national energy narrative, as described in section. That this was following media publication also includes the global comparisons identified in figure 1, demonstrates the power that quantitative geo-imaginaries possess (Renner and Giampietro (2020)):

> “The Karoo Basin is estimated to hold around 209 trillion cubic feet (Tcf) of technically recoverable shale gas resources, although a 2017 study suggested it may be closer to 13 Tcf. If even 5 Tcf is extracted, it could supply electricity for up to 30 years through gas-fired power plants” (Business Day, 2023e)

The power of diverse geo imaginaries was also found to be evident during the interview process:

> “I believe it is a potential game changer. In all respects, across the board! Sort of an organic way of developing our economy […] a systemic boon” (participant 14)

Kuchler and Bridge (2023) argue that the objective of certain resource-making practices is to encourage speculative market activity. This was found to be the case in RSA. In the following example, the position of the ANC and their subsidiaries at PASA is explicitly to create a competitive market for their shale concessions:

> "We are potentially looking at a minimum of about 10 shale gas blocks in the Karoo that will be released through competitive bidding" (Sayidini (PASA), 2023h)

> "What we are proposing to the [DMRE] minister is that we must subdivide the area [of the Karoo Basin], and only licence by invitation, we do not want to award these licences on a first come first served basis […] The problem [with applications that cover such large areas] is that you will end up having one company that controls the pace and scale at which SA can move with shale gas exploration and production" (Masangane (PASA), 2023e)

It looks as if these quotes exemplify an attempt to facilitate what Kuchler and Bridge (2023 p. 7) describe as “a site of potent speculative activities, in which value is not attached to the resource itself, but in its value as a tradeable commodity. This position is reinforced to some degree by the fact that it was acknowledged by PASA at the time of these announcements, that it could be many years before any commercial resources are realised, which again is evidence of the contradictory temporality potential of speculative resource estimates:

> “It could take a decade or longer for the first gas output, if sufficient resources are found” (Sayidini (PASA), 2023h)

The tradable element of shale concessions, and the way in which they are allocated, was also identified in as by a legal expert in the interview process:

> "It's environmental consultancies […] which makes one think, that as soon as those exploration rights are granted, and that is the curious dispensation, that if you are the holder of an exploration right (ER), you are given an automatic entitlement to apply for a production right, as soon as those ERs are obtained, I think they'll sell it on" (participant 9)

The announcements of the concessions were also embedded within a sustained narrative of technoscientific promises and geo-imaginaries, where positive analogies and comparisons are made, and a "multiplicity of future possibilities" mobilised (Kuchler and Bridge (2023 p. 7). In the following media statement, it is made particularly clear the ease with which the revised PASA estimate were still able to be fitted with the international comparisons first mobilised by the EIA report:

> "[209 Tcf] is not insignificant compared with estimated reserves in other countries. The US Energy Information Agency estimates, for example, that at 1,115 trillion cubic feet China holds the world's largest reserve of technically recoverable shale gas" (Business Day, 2023e)

5.4.6. Counter-framing

High-end speculative assessments, however, were also found in some instances to be counterproductive, particularly in the media ecosystem. This was evident following the publication of de Kock et al.'s (2017) research, which despite concluding the presence of a significant gas reserve, was given a negative reception by a number of stakeholders (a fact probably compounded by the report's title "Deflating the shale gas potential of South Africa's Main Karoo basin"). The nature of these framings suggest that the gatekeepers' estimates were perceived to be exaggerated, and used as "hype" (Ingle and Atkinson, 2015). For example:

> "Shale gas in South Africa: game-changer or damp squib?" (The Conversation, 2017d)

That the de Kock et al. (2017) estimates were significantly lower than those produced by the EIA, and promoted by the gatekeepers, led to negative comparisons, which in turn engendered an epistemic counter narrative, since many of the promises, possibilities, and speculations inherent to the EIA estimates, had a *known* rebuttal. Furthermore, these new estimates generated negative comparisons, so that instead of, for example, RSA shale gas being "one of the largest reserves in the world" (DMREb, Annual Performance Plan), the resource was portrayed as "a tiny resource by global standards [… and] forty times smaller than the known remaining coal reserves in South Africa" (The Conversation, 2017d), a process that Himley (2021) describes as "resource - (un) making". This pattern of broadly negative comparison dominated the media landscape shortly after de Kock et al.'s (2017) publication: for example:

> "South Africa's Karoo basin probably has a 30th of the shale gas deposits that some estimates had suggested, deflating expectations of an energy bonanza" (Reuters, 2017b)

> "Fracking flop – Karoo gas estimates 'overcooked' in more ways than one" (Daily Maverick, 2017c)

There emerged a pattern of stakeholders eager to exploit what was by some considered the exaggerated claims by those promoting the EIA estimates, turning the unknown into the known, and thereby counteracting the horizons of possibility with claims of a new, and better-founded reality. There was evidence of this counterfactual argument being employed in the socio-economic realm, utilising the SGDCK (2016) as a fact-based comparator:

> "Even if 30 Tcf were found, this would translate into less than 2,600 direct jobs (with only 15%-35% of these jobs available to Karoo residents)" (Daily Maverick, 2017c)

The findings were also used to discount some of the economic possibilities, and also to cast doubt on the "gestures" that were being employed by state actors in relation to the need for investment to enable resource mobilisation:

> "The studies to date suggest that it's increasingly unlikely that economically and technically viable gas will be found in the Karoo […] making a large investment in infrastructure, regulatory tools, monitoring bodies, and wellfield development for a resource which may not exist […] financially, politically and environmentally risky" (The Conversation, 2017b)

The new much reduced resource estimate also prompted one prominent anti-shale gas campaigner to directly challenge both the governments utilisation of speculative politics, and also the motivations of private-sector actors:

> “Government policy can be built on overstated reserves. This use of sensational hype and manipulation of the figures helps people to get things in place, but no one bothers to hold the oil and gas industry to account when the estimates are slashed later, […] What the motives might be is difficult to follow, but I think it would be obvious to anyone who follows the oil and gas industry closely. They enjoy investors speculating in their shares, based on access to supposedly huge reserves of hydrocarbons.” (Deal (TKAG), 2017c)

This position was also found in interviews in response to new scientific developments, with specific reference to the initial EIA estimates and its methodology:

> “The whole reason this came up was that 10 years ago or more, the USGS did that famous study about sedimentary basins around the world, and a desktop calculation "welllll, if it's this big, and the gas percentage is that, multiply by this…" and [RSA] came out as the 5th biggest resource in the world, and everybody got incredibly excited, this was going to change the whole economics […] Some vast amount of gas was originally estimated to be present, then it came down, then it came down, then it came down, now it’s come right down!” (participant 5)

It might also be noted that the politics of possibility can be turned against incumbent governments, particularly when, as in RSA, they have held power for significant periods of time. One example of this is an article directly criticising ANC competence, headlining “Why are we still sitting on a gas goldmine in the Karoo[?]” (EP Herald, 2022b). This example, directly referencing the DMRE webpage, uses the estimates to emphasise the wasted potential, suggesting that contradictory temporalities and their political possibilities can become self-defeating. Was also identified that in response to the governmentality approaches adopted by the gatekeepers in section 5.4.3.3, activists were utilising strategic tactics to block shale gas resource development, notably by tying the process up in RSA’s protracted legal system:

> “If a person can keep shale gas development at bay for long enough, I think renewables are going to become more and more viable, and I suppose the economic case to be made is going to be much more sensible than shale gas in particular” (participant 9)

Finally, given the controversial nature of the shale gas debate, it could be inferred that maintaining high-end resource estimates may increase resistance from certain stakeholder groups. This is demonstrated in a publication produced by WWF South Africa (Fakir, 2015), where the 2011 EIA estimates are used to emphasise the potentially damaging social and ecological ramifications of gas development of this magnitude.

5.5. Conclusion

The aim of this paper was to explore the role of shale gas resource estimates in South Africa in shaping the national narrative of shale gas exploration. The research used a mixed methods approach of semi-structured interviews and document analysis to obtain primary data. The data derived from these processes was integrated with existing critical resource geographies research, and applied at a national level, using known examples of resource estimates, as a basis for a qualitative analysis of shale gas resource development in South Africa. The qualitative analysis was structured around the themes of the politics of possibility and governmentality, the performative potential of speculative resource estimates, and the power of geo-imaginaries and speculation.

It was found the initial EIA estimates set in play a stream of national resource politics and political strategizing, and remain a significant influence on the national energy dialogue to date. This was found to be because of both their continued use by the DMRE, PASA, and the CGS, but also because of the potency of its associated geo-imaginary horizons, and political possibilities. The use of the uncertainty of resource estimates was found to be used as justification for the mobilisation of resources, and these “gestures” were found to feed into the politics of possibility. The use of resource estimates in the framing of geo-imaginary horizons were largely centred around energy security and economic development, and embodied preferable comparisons with other national resource estimates.

The de Kock et al. (2017) report provided a more empirically based resource estimate, and even though this estimate was substantial in the national context, it was largely omitted from the government energy narrative. This omission enabled the continued use of broad geo-imaginary horizons in the national dialogue, and facilitated governmental control of the energy narrative. Conversely, the use of high-end speculative resource estimates was found to be to be the source of counter-narratives, arguing against the development of shale gas resources, exploiting the limited empirical basis of the higher resource estimates.

5.6. References

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5.7. Appendix

i) Agency/publication references and links

Date	Ministry / Agency / Publication	Resource estimates (Tcf) and range	Link
(n.d.)	DMRE / Shale Gas	390	DMRE (a)
2023	DMRE / Annual Performance Plan	n/a	DMRE (b)
(n.d.)	PASA / Onshore Karoo Basins	30-485	PASA (a)
2023	PASA / Seismic Request for Proposals	n/a	PASA (b)
2021	PASA / Integrated Annual Report	n/a	PASA (c)
(n.d.)	CGS / Karoo Deep Drilling Project	390-485	CGS (a)
(n.d.)	CGS / Research Initiative for KDDP	n/a	CGS (b)
02/11/2023	ANC	209	2023 (a)
10/10/2023	Reuters	200	2023 (b)
08/10/2023	City Press / CEF	200	2023 (c)
14/08/2023	IOL	>200	2023 (d)
30/05/2023	BusinessDay	209	2023 (e)
19/05/2023	SA News	209 (13)	2023 (f)
18/05/2023	BusinessDay	209 (13 – 390)	2023 (g)
18/05/2023	Reuters	209 (13 - 390)	2023 (h)
18/05/2023	Al Jazeera	209 (13 - 390)	2023 (i)
13/01/2023	BizNews	205 (30 - 485)	2023 (j)
13/01/2023	BizNews / PASA	209	2023 (k)
04/01/2023	BizNews	200	2023 (l)
14/07/2022	CNBC	13 - 390	2022 (a)
07/04/2022	EP Herald	390	2022 (b)
18/05/2021	BusinessTech	390	2021 (a)
21/11/2017	Mail and Guardian	13 (13 - 390)	2017 (a)
28/09/2017	Reuters	13 (13 - 390	2017 (b)
28/10/2017	Daily Maverick	13 (13 - 390	2017 (c)
04/10/2017	Conversation	20	2017 (d)

Table 5.1: Agency/publication references and links

ii) Interview data table

Participant Number	Expertise	Sector	Role
1	Hydrogeology, governance, unconventional oil and gas (UOG)	Private	Consultant
2	Hydrogeology, governance, unconventional oil and gas (UOG	Academia	Researcher
3	Geology, hydrogeology	Private	Director, principal geologist
4	Hydrogeology, governance, policy	Government	Scientific manager
5	Systems ecology, environmental science	Academia	Policy development, researcher
6	Governance, social theory, citizen participation	Academia	Researcher
7	Ecology, human ecology	Academia	Researcher
8	Chemical engineering, air quality	Academia	Researcher
9	Environmental law, policy development	Private	Lawyer, lobbyist, community stakeholder representative
10	Engineering, gas	Government	Principal engineer
11	Hydrogeology	Private	Consultant
12	Physics	Academia	Researcher
13	Geology; hydrogeology	Academia	Researcher
14	Midstream and upstream oil and gas	Private	CEO, executive director
15	Energy, systems transition	Private	Policy advisor
16	Hydrogeology	Public / private	Hydrogeologist

Table 5.2: Interview participant information

iii) Timeline table

Ref #	Date	Event
1	1976	The Council for Geoscience (CGS) investigates the oilshale potential of the Whitehill Formation on the western flank of the Karoo Basin. They drill 16 core boreholes in the area between Strydenburg and Hertzogville. This study, together with all available borehole logs and cores over the whole extent of the Whitehill Formation, and that intersected the Whitehill Formation, form the basis of the majority of shale gas resource estimates for the Karoo that have been made to date (Hobbs *et al*. 2016)
2	1968	Soekor finds promising oil & gas reserves in Soekor borehole CK1/68 in the Eastern Cape (James 2016)
3	2010	Shell submits exploration licence applications (de Wit 2011)
4	2011	The US Energy Department estimates that the Karoo basin has 485 trillion cubic feet (Tcf) of Technically Recoverable gas (EIA 2011)
5	April 2011	A moratorium on oil and gas exploration in South Africa is instated (Hedden *et al*. 2013)
6	11 November 2011	The South African government publishes the National Development Plan, stating that shale gas could contribute to electricity generation in South Africa (NPC 2011)
7	September 2012	The cabinet lifts the moratorium on oil and gas exploration and recommends that regulations be drafted to protect the environment (RSA 2019)
8	June 2013	EIA revised their volumetric estimate of Technically Recoverable gas down from 485 to 390 Tcf stating, “reduced area due to igneous intrusions” EIA (2013) pp1-9
9	15 October 2013	The draft technical regulations on hydraulic fracturing ‘the fracking regulations’ is published (RSA 2013)
10	December 2013	The Centre for Environmental Rights, academia and other stakeholders comment on the draft fracking regulations, view it as inadequate to protect natural resources and call for the drafting of regulations that would do so (CER 2014)
11	February 2015	The Strategic environmental assessment (SEA) of shale gas in the Karoo is commissioned by the Department of Environmental Affairs (Scholes 2016)
12	3 June 2015	The final ‘fracking regulations’ is promulgated by the Minister of Mineral Resources under Regulation R.466 in Government Gazette No 3855 dated 3 June 2015 (RSA 2015a)
13	November 2015	Stern and others apply to the Eastern Cape High Court and Treasure Karoo Action Group (TKAG) and Afriforum apply to the Pretoria High Court to set aside the fracking regulations (RSA 2019a)
14	November 2016	The SEA on Karoo shale gas is completed (Scholes 2016)
15	2016	CGS as per instruction from DME initiates the Karoo Deep Drilling project (KDD) to investigate the potential resources in the Karoo basin outlined by the EIA. (Global Africa Network, 2020)

16	June 2017	A study by de Kock *et al*. (2017) estimates that significantly fewer shale gas resources may be available for exploitation, at approximately 13 Tcf, compared to the 485 Tcf that was estimated to be available by the EIA (2011).
17	17 October 2017	The Eastern Cape High Court sets the DMR ‘fracking regulations’ aside in the case of *John Douglas Stern and Others v the Minister of Mineral Resources* (RSA 2017)
18	16 May 2018	The Pretoria High Court dismisses the TKAG and Afriforum applications to set aside the fracking regulations in the case of *Treasure the Karoo Action Group and Another vs the Department of Mineral Resources and Others* (RSA 2018)
19	April 2018	Shell withdraws South African onshore fracking plans (*Engineering News* 2018)
20	2018	PASA’s internal estimate for shale gas inside the Karoo basin is revised to be 205 Tcf (Petroleum Agency SA, 2018)
21	4 July 2019	The Supreme Court of Appeal sets aside the fracking regulations in its entirety. The court also indicated that the commencement of any UOG extraction activities should not be allowed before regulations to protect natural resources are in place (RSA 2019a)
22	October 2019	IRP for 2019 is published, “indigenous gas like coal-bed methane and ultimately shale gas, could form a central part of our strategy for regional economic integration within SADC” (IRP, 2019)
23	24 December 2019	The Draft upstream petroleum resources development bill is published (RSA 2019b)
24	21 September 2020	The CGS announce Phase 2 of KDDP in Beaufort West. This phase involves CGS establishing a geo-environmental baseline and putting in place environmental monitoring mechanisms around the Karoo basin (M. Arnoldi, 2020). They begin drilling a 33,500 meter stratigraphic hole (Energy Voice 2021).
25	May 2021	The KDDP has drilled to a depth on 2,750 meters in the Karoo basin and have found 55 cubic meters of gas so far (Energy Voice, 2021)
26	July 2022	The Department of Forestry, Fisheries and the Environment (DFFE) publishes draft regulations to protect the environment (RSA 2022a) as well as minimum requirements for the submission of licenses during UOG extraction for public comment (RSA 2022b)
27	19 May 2023	Reuters quoted Petroleum Agency of South Africa (PASA) chief operating officer Bongani Sayidini as saying: “We are potentially looking at a minimum of about ten shale gas blocks in the Karoo that will be released through competitive bidding.” The first competitive auction for oil and gas resources in South Africa is anticipated to happen in 2024 or 2025 when legislation establishing the bid round is passed (2023i)

Table 5.3: An historical timeline of UOG extraction and fracking studies in South Africa (from Esterhuyse, 2023)

6. Paper 3: An analysis of perspective on groundwater governance arrangements relating to the potential development of unconventional oil and gas in South Africa

Hemingway, J.R., Gormally-Sutton, A. An analysis of perspectives on groundwater governance arrangements relating to the potential development of unconventional oil and gas in South Africa. *Hydrogeol J* (2023). https://doi.org/10.1007/s10040-023-02742-2

A B S T R A C T

An analysis of expert perspectives on groundwater governance arrangements in South Africa is presented, particularly those arrangements that pertinent to the complex and socially and ecologically significant implications of exploiting unconventional oil and gas (UOG). The paper presents a detailed assessment of literature on groundwater governance research, the findings of which are applied as a framework for a series of expert interviews, comprising hydrogeologists, lawyers, engineers, and governance specialists. This methodological approach was adopted as a means to enable analysis of opinion on the current situation of groundwater governance in South Africa and how fit-for-purpose this is for managing the exploitation of UOG. The analysis was also informed by observation of participants at several relevant decision-making and stakeholder events. Whilst the findings indicated a generally positive evaluation of the initial steps taken to assess UOG impacts and engage relevant communities, recurrent criticisms also featured across the interviews. Key implications arising from the research include: 1) the need for continued stakeholder engagement, and government follow-through on the outcomes of these processes, 2) the necessity for detailed groundwater-specific regulations to be drafted at the earliest opportunity, to ensure that the energy policy vacuum does not have a negative knock-on effect for effective groundwater management, and 3) the prevalence of significant governance gaps, particularly regarding regulatory and institutional capacity, and the need for continued development of a functional network of institutions to effectively manage UOG exploitation alongside groundwater resources.

Keywords:

Socio-economic aspects, groundwater governance, unconventional oil and gas, decision making, South Africa

6.1. Introduction

Groundwater governance arrangements in South Africa are discussed in this paper and, in particular, those pertinent to governing the complex socially and ecologically significant implications of exploiting unconventional oil and gas (UOG) are addressed, as this exploitation is increasingly being proposed and promoted within policy and business communities. It is speculated that South Africa has potentially significant shale gas reserves, but has not yet moved to substantially exploit these through regular or other means of unconventional production. If it does, groundwater needs to be effectively governed, but how fit for purpose the current governance arrangements are, in the face of this challenge, is a matter of some debate. In order to consider the perspectives of those with expertise on the potential interaction between UOG and groundwater governance in South Africa, a set of interviews with relevant actors was carried out, comprising hydrogeologists, lawyers, engineers, and governance specialists. The interviews followed a structure informed by a review of recent groundwater governance research and were used to establish where expert consensus exists and identify areas of critique and dispute. While there has been some research focused on the potential interaction between groundwater governance and UOG in South Africa (Pietersen et al., 2021), these have primarily been limited to a small number of studies specifically focusing on the regulatory framework in South Africa (see Esterhuyse et al., 2022; Esterhuyse et al., 2019; Pietersen et al., 2021). The contribution of this paper is to broaden the scope of this area of study, to build more substantially and systematically on existing knowledge and experience, and thereby to inform decision-makers involved in protecting and managing groundwater resources in cases where they might be subject to disruptive and potentially detrimental activities, such as those outlined in section 3.1.

The paper begins by providing an overview of UOG in South Africa, followed by an in-depth literature review of groundwater governance. It then provides a methodological outline of how these approaches will be applied. The paper concludes with a narrative outlining the findings of the research and provides some recommendations that could help improve the effectiveness of groundwater governance prior to, and during, UOG production processes, both in South Africa, and more widely.

6.2. Study area

6.2.1. Unconventional oil and gas in South Africa: a brief overview

For the purpose of this paper, and to ensure consistent application of terminology, the definition, which includes extraction processes applied to unconventional oil and gas, is that used by the South African Department of Water and Sanitation (DWS), that is:

“unconventional" in relation to oil or natural gas means oil and natural gas that is produced by means that do not meet the criteria for conventional production and requires stimulation including shale gas extraction, coalbed methane and underground coal gasification” (Government Gazette 44545 of 7th May 2021 p. 46).

Between 2009 and 2011, the United States Geological Survey (USGS) conducted a geology-based assessment of 171 (global) geological provinces to summarise the potential for undiscovered oil and gas resources. From this study, and follow-up research, it was estimated that there was a “technically recoverable mean resource of 44.5 trillion cubic feet of shale gas in the Karoo Province of South Africa and Lesotho” (Brownfield et al., 2016 p. 1; 44.5 trillion cubic feet (Tcf) / 1260 billion cubic meters (bcm)). Using known geological characterisations in South Africa, including carbonaceous marine shale persistence and thickness, burial depths, and vitrinite reflectance (Pietersen et al., 2021) a “sweet spot” (figure 1) was identified in the southwestern Karoo Basin as the most prospective target for profitable UOG production. Since then, Petroleum Agency South Africa (PASA) have further refined the target area to reflect ongoing geological data collection.

The potential economic benefits of these reserves triggered global interest from multinational petroleum companies such as Royal Dutch Shell, and a series of exploration licences were submitted to the Department of Mineral Resources and Energy (DMRE), but, following significant public backlash against the proposed developments from both civic and agricultural lobby groups (*e.g.* Treasure the Karoo Action Group and Agri SA) that resulted in legislative action, a moratorium was imposed by the South African government on the production of UOG in 2011 (and subsequently lifted in 2012). In 2019, South Africa promulgated its Integrated Resource Plan (IRP, 2019), which confirmed its commitment to using conventional natural gas as part of its future energy mix, and, although not explicitly confirming its commitment to UOG, left the door open to including indigenous, unconventional oil and gas resources in this mix by stating:

"Indigenous gas like coal-bed methane and ultimately shale gas, could form a central part of our strategy for regional economic integration within SADC [Southern African Development Community]" (DMRE-IRP, 2019 p. 13).

Given this policy uncertainty, and the potentially significant socio-ecological ramifications should UOG exploitation occur, it is proposed that a detailed assessment of groundwater governance arrangements in South Africa could provide valuable insight for policy-makers and those involved in groundwater management.

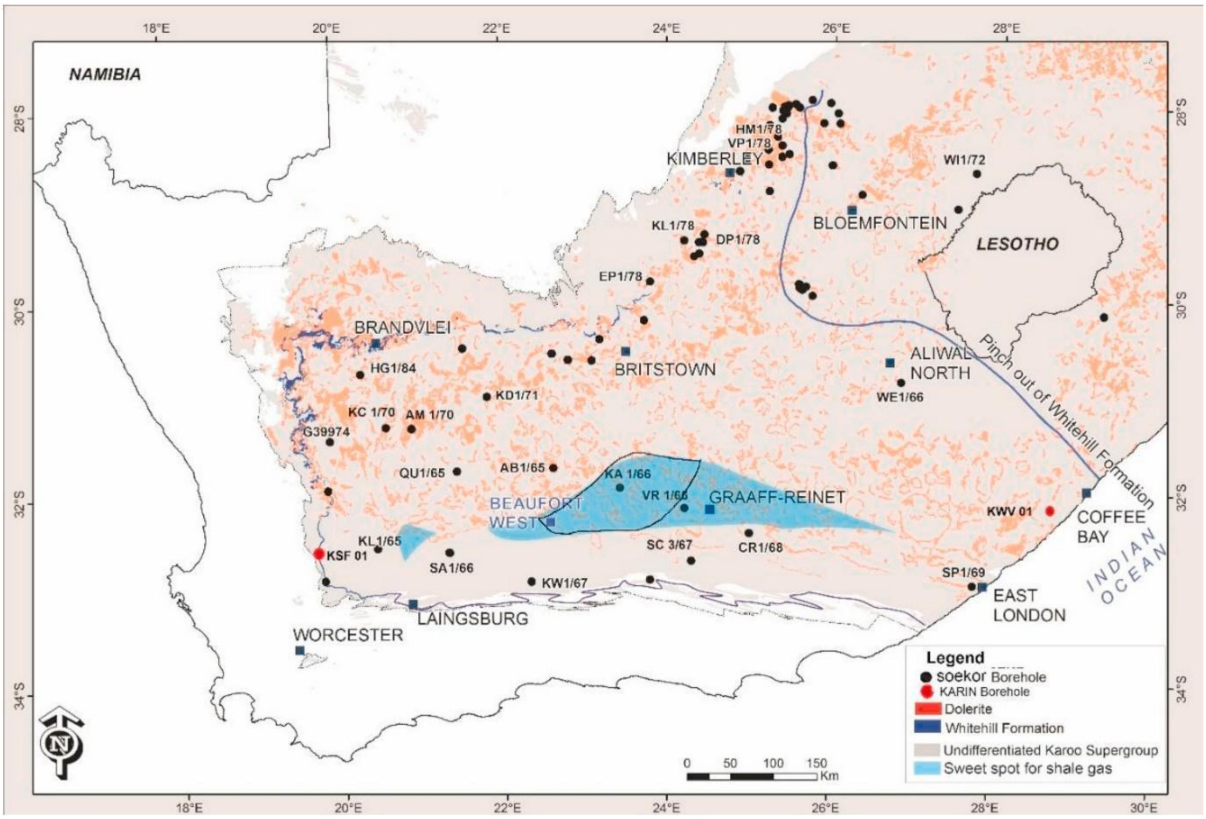

Figure 6.1: The South-western Karoo Basin, South Africa, including: (i) the extent of the outcropping Whitehill Formation and its eastern limit; (ii) the SOEKOR boreholes and two KARIN boreholes; (iii) the "sweet spot", an area of high potential for shale gas exploration; (iv) further delineation of the sweet spot by Mowzer and Adams (2015). (Source: Pietersen et al., 2021)

6.2.2. Water security and energy in South Africa

South Africa is currently facing both an energy and water crisis; rolling blackouts, or "loadshedding", are recurrent owing to the over-reliance on an ageing, coal-powered electricity grid (Esterhuyse et al., 2022), and are the source of significant economic and socio-political concern; and the country has only recently emerged from a scenario that nearly became the first instance of a modern-day city running out of water, the 2016-2018 Cape Town drought (Gittins et al., 2021). The Karoo Basin is particularly water-scarce; it is characterised as semiarid, has low annual rainfall (100-450 mm yr^{-1}) and very little surface water, and as such, its residents and businesses are heavily reliant on groundwater (Esterhuyse et el., 2022; Le Maitre et al., 2009). More broadly, South Africa faces several other water-related challenges: climatic changes are delaying the onset of annual rainfall, exacerbating drought conditions, and population growth is adding significant pressure to an already stressed supply system (Le Maitre et al., 2009; Molobela and Sinha, 2011). Further, historically under-regulated and mis-managed mineral extraction has degraded water resources, as demonstrated by *e.g.* the instances of acid mine drainage that have contaminated both groundwater and surface water resources (McCarthy, 2011; McCarthy and Humphreys, 2013; Polisi et al., 2021).

It is necessary therefore, to carefully consider how, if UOG production proceeds, groundwater resources can be effectively managed alongside these activities. To this end, an in-depth, global literature review on groundwater governance was conducted, the findings of which were used as a framework for a series of expert interviews, intended to appraise and inform the future direction of groundwater governance in South Africa.

6.3. Literature review

6.3.1. Hydraulic fracturing and groundwater

UOG production has been a controversial development in global energy policy, not least because of the application of the technique of high-volume hydraulic fracturing (HVHF hereafter) or “fracking” to stimulate new fractures and thereby increase the productivity of low-permeability rocks such as shale, coal beds, and sandstone (USGS, 2021).

An in-depth review of the scientific and technical detail of UOG and hydrogeology is beyond the scope of this paper, but certain considerations must be outlined owing to their fundamental importance to groundwater governance. Briefly, UOG exploration and production can potentially pose many threats to groundwater resources; UOG production is often a very water intensive process (see *e.g.* Kondash and Vengosh, 2015; Kondash et al., 2018), and concerns have been raised about the potential of UOG production to damage groundwater resources by: 1) over-abstraction of groundwater; 2) HVHF operations affecting the integrity of an aquifer by altering its geological structure or contaminating an aquifer via the upward migration of fracturing fluids; 3) poor wastewater management of both the flowback and produced water which may contain chemicals used in the HVHF process, including radioactive materials and heavy metals; 4: poor well design and poor decommissioning practices allowing the migration of flowback or produced waters into the aquifer (Esterhuyse et al., 2019; McIntosh et al., 2018; Pietersen et al., 2021; Vengosh et al., 2014; Whyte et al., 2021).

6.3.2. Groundwater governance

Groundwater has a number of unique qualities as a common-pool resource that make effective governance difficult: it is invisible, it often has a slow rate of flow, and it is widely distributed (what Villholth and Conti (2018) describe as its "invisible, slow, and distributed" (ISD) signature). Moreover, its management requires both significant expertise and funding. These elements, alongside the rapid increase in demand for groundwater in recent decades, has often resulted in weak or fractured governance (GEF-GD, 2016; Villholth and Conti, 2018). Given the significant social, economic, and environmental functions groundwater provides, its effective governance is therefore essential.

6.3.2.1. Groundwater governance: key themes, and lessons learned

Groundwater governance is a relatively new discipline, but recent years have seen several key developments. Perhaps the most notable among these are the Global Environment Facility (GEF) *Groundwater Governance Project*, a comprehensive review of global groundwater governance issues (see table 1), and the publication *Advances in Groundwater Governance* (Villholth et al., 2018), a four-part book, bringing together expert opinion and analysis of the various elements that comprise groundwater governance, both in its theoretical background and practical application.

These two works provide the most authoritative and comprehensive existing studies of groundwater governance, and their findings are used as a framework for the review of literature that follows.

Project Description	Summary	Overview	Outcomes

Title: “Groundwater Governance - A Global Framework for Action”. *Funding*: GEF Trust Fund. *Implementing Agencies*: Food and Agriculture Organization (FAO). *Executing Agencies*: UNESCO; International Association of Hydrogeologists (IAH)	“The global environment objective (GEO) of the project is to accelerate improved groundwater resource governance at transboundary, national, and local levels. The project development objective (PDO) is to sustain livelihoods reliant upon groundwater and related aquifer services” (GEF, 2020)	Phase 1: An overview of the state of knowledge of global GWG, comprising a conceptual framework, regional case studies, and a series of thematic papers	1: *Global Diagnostic on Groundwater Governance* (GEF-GD, 2016) 2: *Thematic Papers on Groundwater* (GEF-Thematic Paper, 2016)
		Phase 2: A set of targets and objectives for the GWG community, and an action plan for how these might be achieved by 2030	*Global Framework for Action to Achieve the Vision on Groundwater Governance* (GEF-GFA, 2016)

Table 6.1: Table summarising the Groundwater Governance (GWG) Project.

6.3.2.2. Defining groundwater governance

The definition of groundwater governance has evolved over time (see Villholth et al., 2018 p. 9-11) in part due to the relatively recent development of the subject, but also reflecting the shifting priorities of influential stakeholders (*e.g.* the GEF). For the purpose of this paper, the definition used is that proposed by Villholth and Conti (2018 p. 14):

…the framework encompassing the processes, interactions, and institutions, in which actors (i.e. government, private sector, civil society, academia, etc.) participate and decide on management of groundwater within and across multiple geographic (i.e. sub-national, national, transboundary, and global) and institutional/sectoral levels, as applicable.

6.3.3. Groundwater governance project: key themes

Throughout the course of the *Groundwater Governance Project*, the findings of which have been widely reported (see *e.g.* de Chaisemartin et al., 2017; Mechlem, 2016; Varady et al., 2016; van der Gun and Custodio, 2018) a number of elements emerged as fundamental. These were in broad terms: 1) actors; 2) regulatory, legal and institutional frameworks; 3) policies; and, 4) knowledge, information and science (see table 2). The following sub-sections will outline what they each consist of, and what challenges and opportunities they face and present, thereby identifying connections between groundwater governance components, which will in turn provide the framework to address the challenge of UOG development in South Africa.

Key theme	Description

Actors	There are many actors involved in groundwater governance. These include the private, public and third sectors, and come from a wide range of industries. Good governance requires strong stakeholder-participation, and effective cooperation and coordination between the various actors.
Legal, regulatory and institutional frameworks	These define the rights and obligations of both the user and the administrative authority, and provide a starting point for policy development. It is necessary to have coordinated legislation that is up-to-date and that reflects the socio-ecological realities on the ground.
Policies, management and planning	For groundwater governance to be effective, water policy between different sectors needs to be coordinated, to create a suitable spatial and temporal fit for the challenges. This may involve redrawing traditional governance boundaries, or creating more long-sighted policies.
Knowledge, information and science	Both physical information and socio-economic factors associated with groundwater uses need to be considered when designing and implementing governance strategies. Good groundwater governance therefore must be adequately funded to enable sufficient data collection, and the data must be shared between different sectors and clearly communicated.

Table 6.2: An overview of key themes identified in the Groundwater Governance Project

6.3.3.1. Actors and models of governance

There are numerous and diverse actors involved in the abstraction, management and governance of groundwater. These include the private, public, and third sectors, all operating at a number of different scales of governance, from local to global (GEF-GD, 2016). The actors can be broadly categorised into three groups: first, those that abstract groundwater; second, those that are in charge of groundwater policy development and management; and, third, professionals that facilitate the implementation of groundwater policies (van der Gun and Custodio, 2018). But in addition, there are other actors with the ability to impact on groundwater, such as those involved in mining, industrial, or agricultural activities. Effective governance requires the coordination of these actors, and although there is no one-size-fits-all approach, or "panacea" to governance (Ostrom, 1991), certain methods have proven to be more successful than others. Typically, governance structures fall into one of three categories: 1) a top-down "command and control" strategy; 2) a bottom-up, community-driven approach;

or, 3) a combination of the two that involves a centrally coordinated strategy, but includes some degree of stakeholder participation. A breakdown of the different approaches, and their strengths and weaknesses are provided in table 3.

Governance challenges involving actors and different approaches to governance are numerous and varied, including (i) problems of awareness resulting from groundwater's ISD signature (see *e.g.* Eden et al., 2016; Foster and Garduño, 2012; Megdal et al., 2017; Villholth and Conti, 2018) (ii) stakeholder engagement challenges *e.g.* historic mistrust between actors, and over/under representation of certain groups, and difficulties in initially engaging with stakeholders, and then embedding and maintaining their participation into the governance process (GEF-GD, 2016; Mott Lacroix and Megdal, 2016), and (iii) governmental challenges *e.g.* insufficient resource-allocation and lack of clear mandates and transparency (GEF-GD, 2016). Many of these challenges have no easy or definitive solution, and will therefore be ongoing. However, continuing efforts to raise the profile of groundwater should improve awareness and in turn, encourage investment and participation. Furthermore, addressing these challenges can provide a platform for wider societal benefits *e.g.* institutional reforms, greater accountability and transparency and improved trust between actors (GEF- GD, 2016; Villholth and Conti, 2018).

Modes of governance	Strengths	Weaknesses
Top-down governance: Policies, legislation, rights, and obligations prescribed and enforced by a central body (usually state-sponsored)	Some central coordination is necessary for effective governance (GEF-GD, 2016; Molle et al., 2018). Access to available resource *e.g.* funding, information sharing mechanisms, enforcement mechanisms (GEF-GD, 2016).	Governments having poorly defined "fuzzy" or conflicting mandates (van der Gun and Custodio, 2018; van der Gun et al., 2016); central agencies lacking stakeholder trust and having poor accountability and transparency (Guimarães Pereira et al., 2005; van der Gun and Custodio, 2018); groundwater abstraction and management often having a history of self-regulation, which can result in a lack of subscription to prescriptive governance approaches (GEF – GD, 2016), and can reflect unequal power relationships and perpetuate inequalities prevalent in society (GEF-GD, 2016; Ostrom, 1990)
Bottom-up governance: Locally driven approach to decision-making and policy implementation	Can improve perceptions of legitimacy and compliance among stakeholders (de Chaisemartin et al., 2017; Eden et al., 2016; Foster and Garduño, 2012; Megdal et al., 2017). In practice, governance and management arrangements usually have some degree of existing self-regulation (GEF-GD, 2016)	Can lack access to funding, information, and technical expertise(GEF-GD, 2016). Vulnerable to weak leadership, and stakeholder fatigue and frustration, owing to the significant commitment required (Varady et al., 2016). Like top-down approaches, these can also reflect power imbalances, and become dominated by certain groups (Ostrom, 1990)
"From community to cabinet" (GEF-GD, 2016), a combination of top-down and bottom-up	A centrally-driven and resourced, but locally consulted and endorsed approach can generate the most effective and	Can suffer from broader governance challenges, such as: underfunding and under-resourcing; shortage of technical capacity; weak or poorly mandated policy; fragmented governance; power

approaches designed to mitigate their respective weaknesses and embrace their strengths	manageable policies, with high perception of legitimacy and compliance – often incorporating existing arrangements (GEF-GD, 2016; Varady et al., 2016; Villholth and Conti, 2018). Stakeholder participation identified by Ostrom in her *Design Principles* as essential for effective common-pool resource (CPR) governance (Ostrom, 1991)	imbalances; and, conflicting policies (Megdal et al., 2014; Molle et al., 2018)
Polycentric governance: Multi-level, governance system, where actors from different sectors operate and interact at different institutional levels.	An interactive governance model that can facilitate effective stakeholder interconnections both vertically through institutional levels (*e.g.* between local government, central government and supranational institutions) but also horizontally between stakeholders at the same institutional level thereby improving the transmission of information, and effectiveness of institutional response (Cash et al., 2016; Ostrom, 2010)	The inherent complexity of polycentric governance systems has been identified as both a strength and weakness. The complexity is designed to target the "wicked" nature of certain governance challenges, but in doing so can create or mask more obscure challenges, such as complex institutional power dynamics (Morrison et al., 2019).

Table 6.3: An overview of typical approaches to groundwater governance, and their relative strengths and weaknesses.

6.3.3.2. Legal, regulatory and institutional frameworks

Legal, regulatory and institutional frameworks are crucial for effective groundwater governance. They define the rights and obligations of both users and of administrative authorities, and form the basis of more refined policy development (Burchi, 2018; Chaisemartin et al., 2017; Mechlem, 2012). Legislation must be designed in accordance with existing institutional capacity, so that it can be effectively implemented, regulated, and where necessary, enforced. Furthermore, its design and implementation must consider existing water use and customary water rights (GEF-GD, 2016).

Groundwater legislation has in recent years come to reflect a shift in perceptions including the acknowledgement that groundwater is a finite resource, and that groundwater resources, although common-pool, need to be treated not as open-access resources, but as a public good, which inevitably means some degree of state intervention in its regulation (Garcia et al., 2018; GEF-GD, 2016; Mechlem, 2012). Legislation, therefore, typically addresses: groundwater abstraction: *e.g.* drilling permits and setting volumetric abstraction limits and rates; environmental protection: *e.g.* pollution prevention and ecosystem protection measures; and, social policies and human rights, including improving access to clean water.

Establishing workable legislation provides a framework for policy, but its application presents many challenges. Administration, implementation, and enforcement of legislation are fundamental aspects of groundwater governance, and are areas which have been identified as often weak or unsatisfactory (GEF-GD, 2016). Several reasons have been identified as the underlying causes of these failures, including laws contravening customary law or existing water rights (Burchi, 2018; Llamas et al., 2015; Mechlem, 2015; Roth et al., 2015), prohibitive costs associated with compliance (GEF-GD, 2016), a social culture of non-compliance (GEF-GD, 2016; Zubari, 2013) and a lack of human, financial and technical capacity to implement and enforce legislation (Foster and Garduño, 2012).

If legal reform is necessary, it is not an instantaneous process, but if it is done correctly, it has the capacity to be beneficial by discarding outdated regulations, ensuring that new legislation minimises policy fragmentation, and introducing enforceable laws that incorporate modern socio-ecological goals and aspirations, and which adopt the current best technological practice to achieve these ends (Villholth and Conti, 2018; Foster and Garduño, 2012).

6.3.3.3. Groundwater policy and management

Although necessarily interconnected, there is in practice a distinction between legal, regulatory and institutional frameworks, and policies and management. Legislation provides a framework within which policies must be developed, but developing and enacting laws is a slow process, and once in place, they are difficult to amend. Management strategies on the other hand are location-specific, and are the tools and activities that are used to achieve policy. Policies are the link between the two. Policies set goals, they represent societal preferences (*e.g.* means of energy or food production), and reflect societal structures, such as top-down or bottom-up approaches to governance. They incorporate principles (*e.g.* the polluter pays principle, and the precautionary principle), and establish the processes to achieve these ends (*e.g.* through Integrated Water Resource Management (IWRM)) (GEF-GD, 2016; GWP, 2018; Varady et al., 2012; Varady, 2013). As with most aspects of groundwater governance already discussed, the approach policymakers adopt is influenced by local realities. Determining factors include the relative role of the state and private sector in policy formulation (GEF-GD, 2016), the likelihood of compliance, and whether to rely on hard instruments, such as legislation, or to adopt a softer approach such as applying incentive or disincentive schemes. There is an ever-increasing body of academic literature comparing groundwater governance policy (see Part 4 in *Advances in Groundwater Governance* (Villholth et al, 2018); Ross and Martinez-Santos, 2009; Ross, 2017; and, Varady et al., 2012), and common challenges can be drawn out of this work.

6.3.3.4. Knowledge, information and science

In principle, there is an abundance of knowledge, information and science that can facilitate groundwater governance. This ranges from detailed groundwater assessments to the socio-economic data of regional groundwater users, information coming from multiple disciplines and a range of sectors, therefore outlining all such potentially useful data, is beyond the scope of this paper. Key conclusions from the literature on this theme are as follows:

- *Groundwater assessments*: Robust groundwater assessments are fundamental to effective groundwater governance. As a minimum these should include: 1) a hydrogeological characterisation – an assessment of the interaction between groundwater and ecosystems; 2) an assessment of the groundwater-food-energy nexus; and, 3) the economic services provided by the groundwater resource (IGRAC, 2020). Consideration of the temporally variable aspects of these factors, *e.g.* variable recharge, changing agricultural practices, population growth, and climate change is also needed (GEF-GD, 2016; Villholth and Conti, 2018).
- *Data sharing*: The GEF found data sharing of information relevant to groundwater governance to be limited, and often not suited to different actors (GEF-GD, 2016). It was therefore recommended that policymakers foster cooperation with the private sector, create structural provisions to facilitate data collection, and data and information

distribution, and to encourage the tailoring of information to specific groups (GEF-GD, 2016; Villholth and Conti, 2018).

- *Quantitative indicators*: Defined baseline measurements for water quality and quantity, alongside monitoring systems that can provide advanced warning, are advisable to improve disaster-preparedness and increase system resilience (Pietersen et al., 2016; Varady et al., 2016).
- *Knowledge production*: Citizen science, or the co-production of knowledge, has been proposed as a means of addressing many of the challenges addressed so far, by creating and reinforcing stakeholder participation and by promoting awareness (Mott Lacroix and Megdal, 2016; Varady et al., 2016).

Addressing all these aspects of groundwater governance is costly, time-consuming, and require skilled personnel, which, depending on socio-economic realities, may make them difficult to achieve. Improved remote-sensing and technological advancements are improving the ability to collect, store, manage, analyse and distribute data, and reducing the need for *in-situ* fieldwork (GEF-GD, 2016; Varady et al., 2016), but there are still significant barriers associated with this aspect of groundwater governance. That said, although access to good data, science and information is obviously beneficial, gold-standard knowledge information and science is not essential, so its absence should not be used as an excuse for inaction (Varady et al., 2016).

The findings from this literature review provide valuable insight into common challenges that can impact effective groundwater governance. It is therefore proposed, that by recognising this existing knowledge and global experience, it will be possible to apply this information to ongoing or developing groundwater governance scenarios, to help mitigate potentially deleterious socio-ecological impacts, and facilitate effective management of groundwater resources.

6.4. Methods

The objective of this research is to use existing groundwater governance research to provide a framework for data collection of expert perspectives on current groundwater governance arrangements in South Africa. Data collection included both expert interviews, involving relevant actors, and participant observation of a number of significant events regarding decision-making processes pertinent to groundwater governance and UOG development in South Africa.

The research focussed on the four areas of groundwater governance that were identified in the literature review as fundamental to effective groundwater governance: 1) actors; 2) regulatory, legal and institutional frameworks; 3) policies; and, 4) knowledge, information and science. Interviewees were therefore identified owing to their relative expertise in these areas of research in South Africa, both in the fields of groundwater and UOG, and also in environmental governance more broadly. Sixteen interviews (and several follow-up interviews) were carried out between 2020 and 2023, both online and in-person; all interviews were semi-structured, thereby enabling the research to adhere to the broad governance framework established in the literature review, but to also allow participants the freedom to provide detailed responses according to their areas of expertise. The questions posed to participants were relevant to their expertise. Participants were approached throughout the course of undertaking the literature review and chosen according to the relevance of recently published works, with further participants contacted by recommendation or introduction of existing participants. The participants were largely based in South Africa, although there was some international input to mitigate knowledge gaps that may have arisen owing to UOG development in South Africa still being in its early stages. There was a high positive response rate from people approached, with stakeholders from many of the sectors identified in the literature review agreeing to take part. (see Table 4)

In addition to one-on-one interviews, the research included a participant observation element, where several relevant events were attended, including events organised by SADC-GMI (Groundwater Management Institute) (events in 2019, 2021 and 2022), DWS (event in 2021, Council for Geoscience (CGS) (event in 2022), South African Oil and Gas Alliance (SAOGA) (event in 2021), alongside visits to academic institutions, and other private sector actors involved in UOG and groundwater governance research. This enabled the research to have a "live" aspect to it, as it provided an opportunity to directly observe key governance operations, such as policy drafting, lobbying, and feedback from stakeholders. Further, it provided a platform for the research to pose questions to a wider audience *i.e.* delegates or speakers, and participate in group discussions.

All interviews were transcribed, and all events attended were recorded where permitted and practicable, or if not, field notes were taken. Transcripts were then subject to qualitative analysis and coding, using F4 Transcript software. Transcripts were coded according to the pre-determined research framework (see above), and were further sub-coded into subject groups as they occurred. In this process there emerged a *picture* of where consensus exists, identified areas frequently cited as of concern, and also highlighted areas of ongoing debate and discussion.

Participant Number	**Expertise**	**Sector**	**Role**
1	Hydrogeology, governance, UOG	Private	Consultant
2	Hydrogeology, governance, UOG	Academia	Researcher
3	Geology, hydrogeology	Private	Director, principal geologist
4	Hydrogeology, governance, policy	Government	Scientific manager
5	Systems ecology, environmental science	Academia	Policy development, researcher
6	Governance, social theory, citizen participation	Academia	Researcher
7	Ecology, human ecology	Academia	Researcher
8	Chemical engineering, air quality	Academia	Researcher
9	Environmental law, policy development	Private	Lawyer, lobbyist, community stakeholder representative
10	Engineering, gas	Government	Principal engineer
11	Hydrogeology	Private	Consultant
12	Physics	Academia	Researcher
13	Geology hydrogeology	Academia	Researcher
14	Midstream and upstream oil and gas	Private	CEO, executive director
15	Energy, systems transition	Private	Policy advisor

16	Hydrogeology	Public / private	Hydrogeologist

Table 6.4: Profiles of interview participants

6.5. Qualitative narrative and discussion

The following discussion is an analysis of the findings of the interview and stakeholder engagement processes. Using the framework drawn from the literature review. It provides an in-depth analysis of a range of expert opinion, which will in turn be used to draw conclusions, and provide a series of recommendations. All quotes are derived directly from primary data collection, *i.e.* interviews or participatory events, and are reproduced with the permission of interviewees.

6.5.1. Actors

When the potential for large scale UOG exploitation was identified in South Africa in the early 2010s, scientists and academics quickly identified the need to begin meaningful and representative stakeholder engagement processes to ensure that all relevant stakeholders would have a platform to convey their knowledge and expertise, and also to voice their concerns and reservations. To this end, in 2015, staff at the national research institute, the Council for Scientific and Industrial Research (CSIR), approached the South African government to propose a systematic scientific assessment be carried out, to address what they perceived as the *ad hoc* approach that different stakeholders had been using up until then, and to provide a means of addressing the problems that were already beginning to emerge:

> "The shale gas thing was developing in a very unhealthy way. It got very polarised very early, and people on either side of the divide weren't listening to each other, just throwing rocks at each other" (participant 5)

From these early discussions, it was concluded there was a need for an open scientific assessment, that brought together experts and representation that covered all pertinent aspects of the complex social and ecological practice of UOG exploration, and to create a multi-author team that represented "a diversity in the different disciplinary approaches, but also genders, ages [and] origin[s]" (participant 5). It was suggested that by adopting this approach (one similar to those already employed by *e.g.* the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)), it would be possible to gain an understanding of the spread of legitimate tested opinion. The outcome of this process was the publication of the 2016 strategic environmental assessment *Shale Gas Development in the Central Karoo: A Scientific Assessment of the Opportunities and Risks* (SGDCK hereafter) (Scholes et al., 2016), a comprehensive assessment that addressed 18 questions over 1400 pages.

The SGDCK provided a meaningful framework for stakeholder participation, and was broadly well-received, from "both the petroleum industry side, and the environmental non-governmental organization (NGO) side" (participant 5). It was credited with bringing together factions that had up until that point refused to engage:

> "People said "You'd never ever get these people to sit in the same room", but we did, and they all learned something about it. It didn't necessarily mean that they radically changed their positions, but they understood what the constraints were" (participant 5)

The SGDCK specifically addressed water resources in the publication (Ch. 5), and concluded with a section identifying the key knowledge gaps (Ch. 5 pp. 111-115); alongside several technical and hydrogeological unknowns, the need for the DWS to develop effective regulation to manage water resources alongside UOG production was also identified:

> "It is necessary that the DWS develops its own regulations to govern the exploration and development of petroleum resources as soon as possible" (Scholes et al., 2016 Ch. 5 p. 113)

The DWS have begun developing regulations to manage onshore UOG exploration and production (Government Gazette Notice 44545, 07 May 2021), which has triggered multiple stakeholder engagement meetings aimed at bringing together different legal, technical and academic experts. The stakeholder engagement process was generally well-received by interviewees involved in the process, although the length of time the process has taken has come under scrutiny, leading to a reduction in engagement, with the chair of the latest meeting: "*DWS Stakeholder Engagement on Unconventional Gas - Research, Knowledge and Academic 23 November 2021"* conceding the event was poorly attended. This research has found no evidence of stakeholders being actively excluded, it therefore seems likely that the engagement process for the current version of regulations is complete, and, as one interviewee concluded, until the paucity of detail within the regulations is addressed (*e.g.* conflicting definitions; baseline monitoring; penalties for non-compliance; borehole closure) (Pietersen et al., 2021, the focus should not be on further engagement, but addressing identified shortcomings within the current draft.

The effectiveness of the top-down, centralised mode of governance adopted by the South African government has come under scrutiny. It was suggested by interviewees that this approach led to delays in the initial scientific assessments, and raised questions of transparency of the process*:*

> "It took a long time to get government to agree [to the SGDCK], because their natural instinct is not to hold open processes, it is to hold… [the] kind of process, where they control information and determine who does the studies" (participant 5)

South Africa also has a significant NGO and third sector that plays an important part in the development of policy, and have been influential in the ongoing UOG debate:

> "NGO sector is very valuable, coupled with an active citizenry, and an active free media. That's been one on the forces that have actually maintained a lot of accountability" (participant 9)

They also seek to sustain effective communication channels between and within government departments. One example of this is the relationship between the powerful federation of agricultural organisations, Agri SA, who have regular meetings with government ministers, and have been an influential lobby group regarding UOG policy:

> "There's a very strong relationship between [Agri SA, and] all government departments, the DMRE maybe not so much, I think for a variety of reasons, and they obviously know we are often complaining and fighting about things with them, so it's not as cordial a relationship. But it's certainly something we strive for, to engage with different government departments at all times" (participant 9)

Further, research organisations such as the Water Research Commission (WRC), who are mandated to promote coordination and cooperation in water research, are involved in both technical aspects of water research and policy development, and can therefore be effective conduits of information between technical staff and ministers:

> "They are reporting directly to the Minister of Water and Sanitation, so the minister is using them as a soundboard for guidance as well. So, with their research they are providing input into where the minister is going […]. We [in] the Department are actually providing the Water Research Commission information that [then] feeds back to the minister" (participant 4)

6.5.2. Regulatory, legal and institutional frameworks

6.5.2.1. Legal framework

The legal framework in South Africa is widely well-regarded, and the Constitution of South Africa, established following the country's first free and fair elections in 1994, is internationally lauded for its progressive and inclusive legislation, its extensive Bill of Rights, and commitment to environmental protections (see *e.g.* Constitution of the Republic of South Africa, 1996, sections 1; 38; 24) (Cameron, 2018)). The main pieces of legislation that cover groundwater governance and UOG exploration are described by one of the interviewees as:

> "Very good laws, particularly our NWA [National Water Act] and NEMA [National Environmental Management Act], our MPRA [Mineral and Petroleum Resource Development Act] is a well-drafted piece of legislation" (participant 9)

Furthermore, this interviewee goes on to argue that under the constitution, environmental protections should be prioritised over economic activities such as UOG exploration and production, and although it should be noted that this is an individual legal interpretation, and not an established precedent, this reading could in practice be beneficial to effective groundwater governance, as:

> "[the] constitution of the RSA, which holds as a fundamental human right, the right to an environment that is not harmful to the health or wellbeing of its citizens, there's no equivalent provision in the bill of rights of the constitution, that should give precedence to mining. Water, and the requirement for housing and water, these very social rights is supported in the constitution, are also contained in that, so from a legal point of view, I would probably say that you have very strong grounds legally, from a constitutional point of view, read together with NEMA to make one think that the environmental consideration should have precedence" (participant 9)

Further interrogation of the relative precedence of legislation is beyond the scope of this research, however, future legislative decisions will inevitably have an impact on groundwater governance, and therefore this aspect of governance will require continuing attention and revision.

This effectiveness of the legal framework and its appeals process was tested in 2019 in a series of legal cases (Minister of Mineral Resources v Stern and Others; Treasure the Karoo Action Group and Another v Department of Mineral Resources and Others (4 July 2019) in which it was successfully argued that the Minister for Mineral Affairs was not authorised in terms of the MPRA to implement the Regulations for Petroleum Exploration and Production, 2015, and that activities relating to petroleum exploration and production should instead come under the control of the Environment Minister and NEMA, thereby creating a more transparent and accountable process in which there was interdepartmental scrutiny of policy decisions (CER, 2019; EGSA, 2019).

6.5.2.2. Regulatory framework

The regulatory framework for water management as well as UOG extraction in South Africa is a work in progress as highlighted in the legal case Minister of Mineral Resources v Stern and Others, so whilst resolving responsibility for granting exploration rights is a welcome development, there remains a whole suite of regulations that need to be developed and enacted if groundwater resources, and other socio-ecological concerns, are going to be managed effectively during the exploitation of UOG reserves (see Esterhuyse et al., 2019 for a detailed examination of regulatory approaches)

As the SGDCK acknowledged in 2016, it is imperative that the DWS has its own regulations governing the exploration and development of UOG. To date, the regulations “the draft Water Fracking Regulations” (DWS, 2021) covering planning and assessments, water-quality monitoring, site selection, establishment and containment, well management, and hydraulic fracturing remain in draft form. Developing the regulations has involved an ongoing stakeholder engagement process, and participants in this have consistently identified two significant issues with the process: first, the length of time it is taking, and, second, the lack of substance, particularly granular regulatory detail, in the draft.

The slow process in drafting regulations is in part because it is essential that they are well designed, and that once implemented they will be fit for purpose, so there was a general agreement amongst participants that the process is inevitably time-consuming. In addition, there is a creditable procedural protocol in South Africa that requires regulation to be presented to the public for comment, which allows stakeholders the opportunity to engage with regulation development, which in turn allows government to amend regulations accordingly. Nevertheless, the development of these regulations has been protracted, and a source of huge frustration to those involved, as one interviewee noted:

> “Nothing is working soon in South Africa, so everything is going to take some time, so I presume that we will only get this this regulation in let's say three to five years from now. It's taking a very, very long time to get regulations into place” (participant 4)

There have been a number of explanations for this delay. These include institutional capacity (see section 3.3.2), unclear government policies, and unwillingness to commit to regulation for fear of public backlash. There have also been procedural factors cited for the delay, notably the exclusion of experts from involvement in writing the regulations, so that all drafting was done internally, which has restricted both capacity and expertise:

> “[the DWS] wasn't willing to invite anybody from outside, from academia, or industry, and [it] just closed up the whole thing. So, it's only the department internally writing those regulations, and up to now nothing has come out because they just don't know what they are doing” (participant 2)

It was alleged by a number of interviewees that in-depth amendments submitted to government by external parties for review have been ignored, and that technical considerations essential for the effective protection of groundwater resources have either been overlooked, or lack the necessary detail. Outstanding issues include the sealing of abandoned wells, vertical separation distances between HVHF activities and overlaying aquifers, the progress of baseline water assessments, and penalties for non-compliance (see Pietersen et al., 2021). There appears to be, however, a promising consensus among all concerned that the identified shortcomings of the draft version must be addressed, and the process be expediated as a matter of urgency, to ensure the regulations are in place and effective before any further UOG development activities begin.

In addition to regulation directly relating to UOG extraction processes, it is also widely recognised, both outside and within government, that there needs to be regulation for downstream activities associated with any UOG extraction (also known as “fractivities”) that have the potential to damage groundwater resources. These include, though not limited to, technical regulation determining best practice for wastewater transport and disposal, and the effective regulation, monitoring, and accountability framework for subcontracted works, because all these activities have proven to be a significant problem for regulators in the United States (McGranahan and Kirkman, 2019, 2021). There is a further consideration, although it is outside the scope of this research, that social and infrastructural regulations cover additional costs incurred for policing, road maintenance, and other factors associated with developing large industries in rural locations such as the Karoo.

It is clear therefore that although UOG extraction is still unconfirmed in South Africa, it is vital to establish an effective regulatory framework irrespective of ongoing policy uncertainty, to forestall entirely predictable negative externalities that could occur should UOG production proceed, and that policy-makers and regulators draw on the knowledge of the more developed industry in the United States to create a suite of regulations (McGranahan and Kirkman, 2019, 2021), as one interviewee concluded:

> "If people […] would at least take that precautionary principle, if there's a one-percent chance that this could happen, they should have some robust guidelines for how it's going to work" (participant 7)

Having established consensus on the types of regulation that are necessary, there remains the need to determine by whom they will be enforced. The public stance of the DWS (as expressed in their academic stakeholder engagement meetings) is that there is existing departmental capacity to manage the extra workload associated with the regulations, a view not shared by *any* of the research interviewees. An example of these reservations is the already ineffective enforcement of the existing water use licences:

> "The regulations are there, but the actual implementation on ground level, it's non-existent" (participant 4)

This had led to the general agreement that the DWS will need to build capacity within the department, particularly in human and physical resources, or outsource the work to private companies, or more probably, both. As the SGDCK concluded:

> "The likelihood of environmental non-compliance is increased by poorly capacitated regulators, largely reliant on information supplied by the industry" (Scholes et al., 2016 p. 31).

6.5.2.3. Institutional framework

Given the complex nature of exploiting UOG, it is unsurprising that there is a need for a range of institutions, including, *e.g.* institutions involved in research and development, policy-making, and civil engineering, alongside their relevant regulatory bodies, which in turn will necessitate some degree of lateral, polycentric governance to ensure the process is coordinated effectively, as one interviewee with extensive expertise in systems thinking said:

> "You don't just need one institution, it's no use saying "what we're going to do is create the shale gas regulatory agency, okay, job done!" You need a whole ecosystem of institutions" (participant 1)

Owing to South Africa's rich mining history, many of these institutions are already in place, notably in the areas of geological exploration and impact determination. But, as has already been argued, there are significant institutional gaps, particularly when it comes to regulatory institutional capacity. Furthermore, there is also consensus among interviewees that there is a paucity of skills, human resources, and funding, especially at the local and municipal level.

This distinction between national and regional capacity is a product of the top-down nature of South African governance, which has over time become increasingly centralised. One example of this was evident in an interviewee's descriptions of the water use licensing capacity:

> "We've taken that whole exercise away from the regional office, and we're going to centralise in head office. So […] you don't have a lot of capacity, don't have a lot of skill sitting in the regional office, so now you've taken it to head office, where you're sitting with a few experts" (participant 2)

There was also criticism of the historical disbanding of the groundwater department, and dispersing groundwater experts across the DWS, with one interviewee commenting:

> "They separated all of these departmental functions to manage and protect groundwater resources, that must actually be done together, and placed groundwater experts in separate sub-divisions of the DWS. So, they broke up all that groundwater expertise and now there isn't any critical mass to perform the required tasks and also not a proper centralised knowledge base on groundwater within the DWS" (Participant 2)

What emerges from these findings is a picture of disjointed institutional management, underfunding, and human resource shortages. This combination of factors has had a compounding effect that skilled professionals, frustrated with the institutional barriers to effectively discharging their duties, or the "uphill battle", of working within government, are seeking alternative employment in the private sector or academia. In addition, a perception of government department mismanagement may also be deterring young professionals from seeking government jobs:

> "Young people who might be interested in groundwater are not interested in going into government because it's all a shambles, they would rather go work at a consultancy company and get some proper experience" (participant 2)

Finally, there is a perception of endemic corruption at both national and local levels of government, identified by all participants interviewed, which creates an environment of mistrust among stakeholders, and appears to be a significant barrier to effective groundwater governance. The concern therefore is that should UOG extraction works proceed, and contracts begin to be allocated, the misappropriation and misallocation of funds will compound existing institutional gaps:

> "They [the SGDCK] flagged that the regulatory institutional capacity was not only missing, but there were real reasons to suspect it wouldn't function particularly well" (participant 1)

There exists within South Africa significant expertise to effectively manage groundwater resources should UOG production proceed, both within government, government-led institutions, and in the private sector. There is also a substantial body of academic research being carried out concerning groundwater and UOG production. However, given the existing top-down governance structure, it is imperative that central government provides the necessary resources to enable subsidiaries to act effectively. This means, among other things, adequately funding government departments, mandating them to delegate duties at the appropriate governance level, and continuing to root out corruption and cronyism throughout the supply chain. It also seems advisable that the government should utilise the extensive private sector, and encourage public-private partnerships, in order to maximise the skills and resources available.

6.5.3. Policies

South African energy policy is currently in a transitional state. The country has been subject to rolling black-outs or "loadshedding" since 2008, and is in urgent need of additional energy sources (Esterhuyse et al., 2022). The Integrated Energy Plan (IEP) is the umbrella policy outlining how the country will meet its energy requirements, yet a formalised IEP has not been released since 2003, despite a requirement in the 2008 *National Energy Act* that it be reviewed and published on an annual basis (Akom et al., 2021; Yelland, 2021). The Integrated Resource Plan (IRP) is a component of the IEP that considers future energy requirements and how these will be met, last published in 2019, and as already mentioned includes only a brief statement on UOG (see section 3.1). Further policies relating to gas, unconventional or otherwise, need also to be included in the Gas Utilisation Master Plan (GUMP) drafted in 2016, but again, yet to be finalised and released (Yelland, 2021). So South Africa still has no formal policy concerning UOG, although there is an anticipated revised version of the IRP expected in 2023. In the absence of any coherent long-term energy policy, an energy policy "vacuum" has occurred (SANEA, 2021, p. 29), which has had negative consequences, which include the stifling of investment in the sector, and stakeholders competing to promote individual and local interest (SANEA – ERP, 2021). It has been suggested that a lack of leadership and burdensome bureaucratic processes have created a policy environment that is focussed merely on crisis management, and has meant UOG policy remains “uncoordinated and haphazard” (Yelland, 2021 p. 3).

> “We just flip-flop between policy decisions. Some are formalised, some are unformalised, and it all just creates an unhealthy environment” (participant 10)

In addition, this uncertainty creates an unnecessary institutional burden, whereby scant resources are distributed across several areas of the energy sector, limiting any significant action on specific policies, and enabling only insignificant progress on the numerous varied initiatives proposed in the IRP (SANEA – ERP, 2021). This has a knock-on effect for effective groundwater governance, as it creates institutional inertia, hampering financial and human-resources investment in groundwater science and policy research, as one stakeholder noted, when discussing working on UOG and groundwater policy: “there was no progress […] those initiatives all lost momentum” (participant 7).

There is research evidence that identifies significant doubt among groundwater experts that South Africa has the necessary policies to deal with UOG exploitation (Esterhuyse et al., 2021), but given current inaction on any disruptive activities there is time to rectify this. There exists a national *Groundwater Strategy*, that aims to ensure groundwater is recognised and protected as part of the broader water policies, notably the *National Water and Sanitation Master Plan*, but it is further proposed policies must be updated to include data-driven adaptive management strategies to accommodate the development of simultaneous policy pathways involving both groundwater and energy (Pietersen et al., 2021) . Policies need therefore to be developed based on existing knowledge about water resources in the country (*e.g.* lessons learned from the SGDCK), and policymakers need to closely examine policies already adopted in other countries regarding UOG and groundwater, and use these as a framework to build an effective, bespoke policy framework for groundwater governance during UOG exploitation in South Africa (Pietersen et al., 2021).

Finally, policy development will also need to avoid conflict with existing water and environmental policies. There is significant pressure to reduce carbon emissions; to this end, South Africa has established a multi-stakeholder vehicle, the Presidential Climate Commission (PCC) to facilitate a just energy transition. This approach is designed to assist both inter-departmental coherence, thereby avoiding fractured governance scenarios, and ensure community and stakeholder involvement in the decision-making processes. Forming policies that balance lower carbon emissions, alongside developing new gas resources, and managing groundwater will inevitably be a challenging undertaking, reiterating the need for a data-driven policy approach

6.5.4. Knowledge, information and science

As already highlighted, South Africa has significant existing geological and hydrogeological scientific and technical expertise. There remain, however, key knowledge gaps that need to be addressed before any invasive work commences. As a preliminary, it is worth noting that there is still significant uncertainty regarding the presence and volumes of technically recoverable UOG resources in South Africa. This is at least in part because of the country's geological history, and the extensive igneous dolerite intrusions present throughout the region, that it is speculated will have diminished the volume of gas in the shales (Scholes et al., 2016). This is one area in which the research identified quite stark differences of opinion among interviewees; although none of the participants were adamant there exists economically viable technically recoverable volumes of gas, some participants believed the possibility of their existence, and the potentially positive economic benefit they could yield, meaning they were in favour of extensive (and expensive) exploration, whereas others believed it is too unlikely to be worth the expense and social and environmental risk.

The CGS are continuing work on the Deep Drilling Project, a geo-environmental baseline programme designed to further characterise the geological and hydrogeological profile of the southwestern Karoo basin, which it is hoped will in time resolve this uncertainty, but to date, no conclusive evidence has been provided. There was also criticism from interviewees regarding the transparency of the project, frustrating attempts to engage in meaningful collaborative work:

> "They're [the CGS] not very forthcoming with information, they keep their cards close to their chest, and they want to charge you for everything" (participant 13)

This ongoing work does however provide invaluable insights into the hydro-litho-structural domains of the southwestern Karoo (GGS – Deep Drilling Project; Pietersen et al., 2021).

The southwestern Karoo is characterised by a complex and varied hydrogeological system, containing extensive discrete structural features which could provide preferential hydrogeological flow pathways (Pietersen et al., 2021). This has been identified this as a key knowledge gap:

> "There is […] a gap in our identification, understanding and mitigating hydrogeological risk pathways in the context of shale gas exploration in the Karoo basin" (Pietersen et al., 2021 p. 2).

It is therefore necessary to have detailed maps identifying the relative locations of aquifers, target formations, and discrete structural features, information which can then be used to inform a data-driven regulatory approach outlining minimum vertical and horizontal separation distances between aquifers and the HVHF target zone, which can be adapted according to the presence of preferential pathways (Esterhuyse et al., 2019; Pietersen et al., 2021). This adaptive approach would mitigate risk to groundwater resources, and avoid the potential pitfalls of having a prescribed regulatory policy that could prove to be inadequate to protect groundwater resources, or be unnecessarily restrictive to industry.

The SGDCK identified the need for a comprehensive baseline groundwater monitoring network to be in place prior to the commencement of any works, an approach routinely adopted within command-and-control regulations (Esterhuyse et al., 2019; Scholes et al., 2016). Baseline surveys determine water availability and existing water use, thereby guiding policymakers on resource allocation decisions, and can help ensure equitable and sustainable practices. They enable future comparisons to determine changes in groundwater quality, identifying any contamination, and diagnosing potential contaminant sources. They therefore can be important in establishing the basis for any legal claims of contamination, and as such, may be carried out by industry regardless of regulatory obligation to enable companies to refute such claims (Esterhuyse et al., 2019; Esterhuyse et al., 2021). A baseline programme has been established, appointed by PASA, and is being designed and conducted with hydrogeological experts from the Institute for Groundwater Studies (IGS) at the University of the Free State (UFS). This has been a complex and challenging project, but well received within the groundwater community:

> "[the] monitoring data set that they're going to put in place, or monitoring network, will then cover the whole area and cover everything […] that will make a very good network" (participant 4)

Information sharing is a key component of groundwater governance, and an invaluable tool for protecting groundwater resources during UOG extraction processes (Esterhuyse et al., 2019). It is therefore necessary to ensure structural provisions regarding data-collection and dissemination are in place prior to invasive activities. These should include the reporting of all permits issued, details of all planned and existing wells, baseline and monitoring data, and any instances of noncompliance and resulting penalties (Becklumb et al., 2015; Esterhuyse et al., 2019). In addition, detailed water use data must also be provided, including volumes of water used on individual wells, the precise chemical composition of fracturing fluids used on individual wells, and corresponding data of all water volumes and water chemistry returned to surface (Esterhuyse et al., 2019). Energy companies in the United States have objected to this on the basis that disclosure of precise chemical composition of its fracturing fluid formula is a violation of their proprietary trade secrets, but its exclusion from public disclosure causes significant barriers to effective groundwater management. Policymakers in South Africa therefore need to have a clear policy position on information disclosure and exemptions to avoid the legal stalemate that has arisen in many states in the US, and to enable the effective regulation and monitoring of industrial practices in South Africa (Esterhuyse et al., 2019; Esterhuyse et al., 22; Johnson, 21).

Effective communication of data and regulatory transparency is also necessary. To this end Villholth and Conti (2018) propose that provisions for public participation in regulatory and licensing processes are in place, to ensure communications can be tailored to particular audiences, and are readily understood by the public. Having a clear communications strategy and transparency policy is needed to ensure all information can be independently assessed, providing industry social license to operate (Esterhuyse et al., 2019; Villholth and Conti, 2018).

Communication between government departments and stakeholders outside government was also questioned,

> "Unfortunately it feels like If you're a scientist on the outside, you're doing all this work, and all the scientists and academics and consultants […] we share the information with each other and publish it […] Although the publications on groundwater research in South Africa are often publicly available, government always seems to be unaware of the research and they will ask […] did you do any work on this and this? We would reply 'yes!' and would supply them with studies and articles […] and then afterwards you don't hear anything from them again" (participant 2)

This lack of communication creates unnecessary barriers for effective groundwater management, policy and regulation development. It is proposed by a number of interview participants that more transparent communication from government would facilitate both more effective management practices, and also improve trust among stakeholders and the public (GEF-GD, 2016; Villholth and Conti, 2018). It can also help prevent the misuse of information (Esterhuyse et al., 2022), and promote more robust scientific debate:

> “The public debate has been overwhelmed by sectional interests unfortunately, so I think in the public realm a lot of scientific debate got lost” (participant 8)

There are existing data sharing platforms present in South Africa that facilitate groundwater management, such as the government run National Groundwater Archive and the open-access groundwater vulnerability map for UOG extraction, but interviewees considered that more needs to be done to ensure that data are routinely collected and uploaded to these sites so that they can be utilised effectively:

> “What's happening on [the] databases, information is not coming back” (participant 2)

Finally, the role of the media in communicating government policy must be considered. Despite recent serious allegations of state capture of the newsroom (Krige, 2019), press freedom is generally respected, and has been credited with holding government to account:

> “Free and unfettered media has had an enormous contribution exposing the problems and deficiencies of government” (participant 9).

6.6. Conclusions

The purpose of this research was to apply a systematic approach to assessing expert perspectives on groundwater governance in South Africa. To that end, the key findings from recent, comprehensive, groundwater governance studies were amalgamated and used as a framework for a series of interviews with groundwater and governance experts, in order to establish where consensus exists, and areas of ongoing debate. There emerged from this process several consentient conclusions. It was agreed that the initial UOG stakeholder engagement process was extremely effective, and its resultant SGDCK was an excellent publication, built on the experience of internationally acclaimed assessment processes such as the IPCC and the IPBES. All interviewees agreed that the process benefited from effective leadership, and approached the process in an inclusive manner, with only limited criticism of the overall methodology. Further, the legal framework within which policy decisions and processes are to be enacted was also held in high regard by all participants of this research. However, several recurrent criticisms emerged, particularly regarding governmental inaction, the slow development of policy , limited institutional and technical capacity, and transparency of the governance process.

Although some of these problems have no quick-fixes, particularly problems arising from budgetary constraints, this research found agreement that there exists the realistic possibility of significant governance improvement. First, there needs to be a commitment to the precautionary principal, and that prior to industrial mobilisation, there *must* be a confirmed suite of robust guidelines and regulations that covers both primary activities, and secondary *fractivities*. Second, given the government's economic and technical limitations, government departments should further foster cooperation with the private sector and academic institutions, thereby maximising available expertise, that should be used to foster a data-driven approach to managing groundwater resources. Further, this approach would also go some way to addressing the identified mistrust. Finally, a commitment to information and data sharing is needed. There has already been a large body of work produced, and further information and science will inevitably emerge from this process, the findings of which should be used for the public good.

6.7. Acknowledgements

The authors would like to express gratitude to all the interview participants involved in this research. We would also like to recognise the contribution of the late professor Robert (Bob) Scholes, whose early input into the research provided invaluable direction and insight.

6.8. Funding Information and Conflicts of Interest

This research was funded through an ESRC NWSSDTP CASE studentship in collaboration with the British Geological Survey (BGS) University Funding Initiative. The views expressed in this publication are those of the author(s) and not necessarily those of either the ESRC or the BGS. The author(s) have no conflicts of interest to declare that are relevant to the content of this article.

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7. Discussion and conclusions

In this thesis I have explored the development of indigenous gas resources in South Africa. By drawing on existing fields of research, notably (but not limited to) political and resource geographies and the common-pool resources literature, I have attempted to create a body of work to provide insight into different aspects of this complex issue, and to examine ways in which (where appropriate) these findings might have practical applications. These combined aims have shaped the narrative arc of the thesis. By exploring the various positions of stakeholders and their dynamics (Paper 1), the creation and framing of resources and knowledge (Paper 2), and existing governance arrangements (Paper 3), it was possible to bring together knowledge from diverse, but complementary disciplinary fields, which together provide a new way of appraising resource development. Drawing on global literature, but situating my thesis within South Africa, made it possible to apply the theoretical knowledge developed in the course of the research, to a specific, ongoing, situation.

This final chapter addresses how I applied the CPR themes that have been recurrent throughout this thesis, and how these themes have been complemented with other theoretical concepts, notably those emerging from the Just Transition, STS, and critical geographies literatures. This is followed by a discussion of the research questions outlined in section 1.2. to draw on and develop the findings of the research papers, in the process introducing new material from the interview process and data analyses, together with some further interpretations of these findings. I then explore the implications for different groups, and within the broader debate. I have tried as far as possible to avoid repetition, however, for theoretical, structural, and stylistic reasons, at least some crossover between the papers and this chapter proved unavoidable.

The themes identified in the GEF project, 1) actors; 2) regulatory, legal and institutional frameworks; 3) policies; and, 4) knowledge, information and science, have been integral to both the structure and research methods of this thesis. But, as with all theoretical frameworks, it has both strengths and limitations when addressing complex research topics. The structured, governance-centred approach worked particularly well when addressing the case-specific governance challenges outlined in paper 3, however, when tackling research questions 1 and 2, it was found that some extra conceptual tools were required. This following section will identify where and how these additions were made, and the reasoning behind these decisions.

Research question 1 was specifically addressing future gas scenarios in RSA, and with that comes not only an appraisal of the existing energy landscape, but an evaluation of historical practices, and desired outcomes. Because of this, it was necessary to introduce the energy transition literatures as a means of providing richer data, with a more nuanced approach than might have been achieved by presenting only stakeholder opinions, either through data analysis or interview data. By adding this conceptual material to the research process, It was better able to capture the complexity of the energy debate, particularly in a country such as South Africa with its complicated socio-political, socio-economic and socio-ecological landscapes. By using the PCC and its commissioners, the research was able to maintain the key-themes structure, and complement it with different opinions that specifically address energy security, socio-economic, and environmental considerations that are particularly important in research of this nature. It was then possible to link these to ideas to the varying interpretations of “just transitions”. When evaluating the findings, ideas from STS literature informed its conclusions, notably by recognising that not all stakeholders are equal, and that the ANC’s top-down governance approach necessitated an appraisal of the impact this core set would have on the decision-making processes. This, it is hoped, provides a more realistic appraisal of the likely energy scenarios than would have been achieved had the research only focussed on the different opinions held by stakeholders.

In research question 2, where the focus was on geoscientific knowledge, it is apparent that the knowledge that policy decisions are being based on is contested. So, although the key themes specifically address knowledge, information, and science, it provides limited opportunity to address *how* the knowledge is created. In such a contested field, this would be a significant oversight, to remedy which, critical resource geographies was introduced as a theoretical concept. By including these ideas, it was possible to connect the CPR themes, notably actors (in this instance gatekeepers), and geoscientific knowledge, and assess how the uncertainty of the latter feeds into ongoing policy decisions. The critical resource geographies concepts therefore provided the necessary theoretical underpinning to connect the actors with knowledge, information and science, to live policy decisions in what is undeniably a contested knowledge and policy arena.

7.1. Research question 1

How do different actors envisage the role of gas in South Africa's future energy mix, and how are these positions framed? What dynamics and tensions emerge between stakeholder groups?

7.1.1. Introduction: influence, actors, frames, and justice

The role of gas as part of the energy transition is inevitably subject to socio-economic and socio-technical realities, as well as to the existing energy system of a given country (Cantoni et al., 2018). South Africa has a number of factors influencing the present energy policy debate, notably its current energy crisis, its longstanding and continuing reliance on coal, its potentially substantial, and as yet undeveloped, gas reserves, as well as the just energy transition, and the complex legacy of colonialism and apartheid (Snyman and Botha, 1993; Hanto et al., 2022; Ayuk, 2023).

There are numerous actors involved in the development of energy policy, as well as several stakeholders lobbying for and against existing and proposed policies. The positions of the various stakeholders in RSA[47] regarding future gas are also diverse, and in many cases rooted in historical allegiances, in ideological preferences, and in past and present geopolitical dynamics. This diverse basis for policy preference inevitably creates a rich interplay of stakeholder narratives, and engenders a varied, and sometimes surprising, range of stakeholder coalitions and dynamics (Cotton, 2015; Baker and Phillips, 2018; Rennkamp, 2019).

Natural gas as an energy source is in an ambiguous position. It can be categorised as a clean or as a polluting fuel, and as cheap or expensive, which makes it a source of interpretive disagreement in energy policy debate (Janzwood and Millar, 2020). The framings of gas, that is, the "narratives, storylines, or images" (Janzwood and Millar, 2022 p. 2) that go with future

[47] See section 4.2 for political and union affiliations of key government actors, see section 4.8 for PCC Commissioners, and image 3.1 for other actors and their roles.

gas policy are manifold, but also locally specific, and such framing often underpin stakeholder coalitions (Janzwood and Millar, 2020; Scholvin, 2019).

Moreover, justice has emerged as a fundamental concept in the energy transition process (Bouzarovski, 2022; Wang and Lo, 2021). And although there is no agreed definition of justice in this context, there have emerged a set of forms of justice which underpin energy transition, as well as other resource system transformations (Jenkins et al., 2018; Bouzarovski, 2022; Hicks et al., 2022). In a South African context, distributive, restorative, and procedural justice concepts[48] have become most significant and it is these that are applied as the framework for RSA's just transition (Connolly, 2022).

This discussion will endeavour to situate these factors in the current South African energy debate, and in doing so address Research Q2 outlined in section 1.2 of this thesis. Given the scale of this task, and to avoid repetition, the focus of the present discussion will be on energy security, and on the framing of gas as a bridge or transition fuel, though concepts of justice, and socio-economic[49] and environmental factors are integrated into the discussion, as are stakeholder dynamics. The ANC is taken to be the primary actor in this narrative, as, 1: this will enable a critical comparison of divergent frames adopted by other stakeholders; and: 2: it is likely that government policy and entrenched fossil interests often align (Janzwood and Millar, 2022).

7.1.2. Energy security

It is generally accepted that the South African energy landscape is in desperate need of reform. As made clear early in the thesis, despite an impressive national effort to improve the population's access to electricity,[50] millions of people still live without it (Hanto et al., 2022), and a national state of emergency due to loadshedding (see section 4.1) is ongoing. South Africa's energy landscape is still shaped by the socio-political, economic, and spatial, legacy of apartheid (Baker et al., 2014; Baker and Phillips, 2018), it is dominated by an ageing and run-down fleet of coal power stations (Andreoni et al., 2022), and the state-owned utility Eskom

[48] See section 4.3 for a more nuanced appraisal of the systemization and categorisation of the notions of justice, their relevant definitions, and critiques of these approaches.

[49] The ANC's socio-economic framing of future gas is unambiguous. They propose that the exploitation of their indigenous gas resources will create both jobs and deliver a substantial economic windfall, which will be used to fund broader societal goals (*e.g.* "Gas offers a new source of revenue for advancing human development" (Mantashe - Africa Energy Week, 2022); "We will continue to support the development of the upstream gas industry, as it holds huge potential for job creation and broader economic development." (Mantashe - The SONA Debate, 2022a).

[50] It is relevant to this research that much of this improved access was facilitated between 1994 and 2004, with total number of people lacking basic access to energy remaining comparable since this date (World Bank, 2010).

is saddled with a staggering R423 billion debt (National Treasury, 2023). That energy security is high on both the political and civil agenda is therefore unsurprising.

The ANC has been seeking to frame its indigenous gas as a part of the solution to this problem (see section 4.5). From a technical perspective, their principal arguments are that the country needs a stable baseload-energy supply, and that renewable energies cannot provide this. It seems, though, that in presenting their policy choices as *evidence*, the ANC are trying to dismiss alternative framings, and thereby remove the need to engage in empirical, data-driven, debates. For example:

> "The energy crisis highlights the need to have indigenous oil and gas resources as part of the country's mineral resource endowments" (Nkabane, 2022).
>
> "Cognisant that renewables do not provide baseload, we must increase investments in alternative energy sources" (Mantashe, 2022b).

These are not incontestable arguments. First, the energy crisis highlights numerous socio-political and technical failures (Bellos, 2018; Gbadamosi, 2023; Kruper and Burch, 2011), but it does not *necessitate* gas exploration. Second, that renewable energy is unable to meet baseload requirements is to ignore the growing body of evidence to the contrary,[51] and the rapidly-evolving opportunities presented by energy system transformations (ESTs) (Blondeel et al., 2021; Halsley et al., 2023; Rogelj et al., 2013).

These policy preferences reflect the ANC's desire to maintain the existing arrangement of centralised, large-scale, and state-owned energy systems (Baker and Phillips, 2018; CER, 2023), so that any energy system transformation will need to remain within this paradigm. But alternative technical framings of energy security promote a prospect of the EST in RSA as a means to "leap-frog" between energy systems, facilitating a "low-carbon" energy transition (Blondeel et al., 202; Szabó et al., 2013). Further technical framings promote the EST as a means of moving beyond the existing system to a more democratic and decentralised energy system (Wouters, 2016), and one which would facilitate improved energy access (Andreoni et al., 2022; Baruah and Enweremadu, 2019; CER, 2023), at the same time embedding within them justice principles (Venegas Cantarero, 2020).

Offering a mid-term solution to a pressing contemporary problem, moreover, exemplifies the contradictory temporalities and technoscientific promises which were identified in section 5.2.3 (Cantoni et al., 2018; Szolucha, 2023).

[51] An argument sometimes referred to as the "baseload fallacy" (Gets, 2013; Halsley et al., 2022; Lawrence, 2020).

A second energy- security framing of gas adopted by the ANC is based on geopolitical energy supply and security arguments (see section 4.5.1). But there is little evidence of much account being taken of historic and distributive injustices, nor of their legacies, which influence regional economic disparity, and nor of how regional solidarity is framed. In the words of two contemporary commentators:

> “Gas resources can help accelerate and guarantee the continent's energy security,” (Mantashe, Africa Oil Week 2022d, Paragraph 24)
>
> “Our continent deserves the opportunity develop its own oil and gas infrastructure storage, refinery, and distribution to cushion its people against the turbulence of global markets and thereby secure its continental energy needs” (Mantashe, Africa Energy Indaba 2023, Paragraph 42)

To support this energy security position, the ANC has used analogy as a means of justification for its promotion of gas resource development policies. The continued (and in some instances increasing (DiSavino, 2023)) use of gas globally are used as examples, thereby implicitly framing perceived international objection to gas policy as hypocritical, and, by extension, even pursuing neocolonial objectives.

It is in this theatre of debate that particularly fraught counter-framings begin to emerge. It was apparent that stakeholders representing organised labour within RSA's extractive industries were looking to portray the green agenda as a coercive global influence (see section 4.5.1). Conversely, those opposing the continued use, or expansion of, fossil fuel resources, are in turn framing actors within the fossil fuel sphere in a negative light:

> “The Northern powers got rich through the plunder of the colonies, the 3rd World, the global South. The making of wealth and poverty is about relationships of power. In so far as fossil fuel enhanced imperial power, it also became the object of plunder. African elites are colluding with fossil fuel majors who are the agents of neo-colonialism” (groundWork-Report-2022 Contested Terrain.pdf, Paragraph 1110).

It is my contention that these positions represent what Janzwood and Millar (2022 p. 2) refer to as the “escalating tension between the urgency of a post-carbon transition and the pertinacity of fossil fuel consumption”, which, in this instance are compounded by the historic injustices inflicted on the African continent, and by apartheid's complex socio-technical legacy on RSA's energy landscape (Baker and Phillips, 2018).

The typical academic (and South African) response (see section 4.3) to these conflicts is to propose stakeholder engagement, encourage dialogue, and so on (Connolly, 2022; O'Neill-Carrillo, et el., 2010). But, given that these strongly expressed quoted statements are by commissioners of the PCC, which is widely regarded as a prestigious and influential multi-stakeholder vehicle (Connolly, 2022), an ongoing dialogue seems unlikely to reach any acceptable compromise. The complexity of these issues goes some way to explaining the ANC's inability to produce formal policy (see section 4.5.1). It is likely that the top-down, centralised structure characterised by the ANC (see section 4.6), and the uneven influence of stakeholder groups (see section 4.5), will ultimately dictate the outcome of these debates, despite the procedural justice elements embedded in RSA's legislative framework (see section 3.1), and embodied in this instance by the PCC.

7.1.3. Bridge-fuel – pro-gas

The possibility of gas as a bridge or transition fuel (see section 2.4.2) combines the energy security, socio-economic, and environmental considerations of the energy debate. What Janzwood and Millar (2022 p. 8) refer to as the "malleable position of natural gas" captures how gas lends itself to a wide range of interpretive framings.

Policy-makers need to frame their decisions in a way that is likely to attract support, but it is also the case that they can use framing as a way of justifying controversial choices (*e.g.* by identifying trade-offs), as a means of building stakeholder coalitions, and of influencing stakeholder opinion (Janzwood and Millar, 2022; Pralle and Boscarino, 2011). Global studies, however, have shown that the framing of gas from a pro-gas policy-making perspective is regionally specific, and situate policy choices in particular socio-economic, environmental, or security frames (Janzwood and Millar, 2022; Szabo, 2022). This research found evidence of security, socio-economic, and environmental framings all being applied by the ANC, and although no quantitative assessment was made of their relative frequency, none of these specific frames were noticeably dominant. Rather, it was found that the ANC's approach to the bridge fuel concept was to situate it in multiple frames simultaneously, as, for example, a means of energy security and socio-economic development, or as a sustainable way of achieving socio-economic objectives. Such an approach embedded the concept of trade-offs in the narrative, as a way of addressing controversy and building coalitions (Janzwood and Millar, 2022; Pralle and Boscarino, 2011).

This complex pattern of framing may be in part because there's an obvious need for both socio-economic development and improved energy security, but it may also reflect a response to the progressive environmental movement prevalent across Southern African, rooted in historic environmental injustices (Jacobs, 2003; McDonald, 2002). Finally, and not mutually exclusive of the previous suggestions, it may also be a reflection of the ANC and its subsidiary agencies' inconsistent approach to energy policy and promotion, as identified in section 4.3.3.

7.1.4. No-gas!

In contrast, stakeholders who are broadly opposed to gas development have countered these positive bridge-fuel arguments with narratives focussing on environmental protection and degradation, greenhouse gas emissions, and public health concerns (Clarke et al., 2015; Janzwood and Millar, 2022; Matthews and Hansen, 2018). I found that such framings were common, but also found arguments rooted in justice concepts (see section 4.5.3), particularly those addressing the uneven socio-economic benefits historically derived from the extractive industries, for example:

> "Extractivism focused on fossil fuels has in fact brought pollution, poverty and violence to African countries and communities." (Hallows and Munnik, 2022).

This again reflects the importance of local histories and realities in policy framing, particularly important when they involve historic or ongoing violence and oppression, as in this context.

When the anti-gas arguments were applied to shale gas resource development, many of them focussed specifically on water. This again is a likely reflection of the water-scarce environment in which shale gas development is proposed, and of the region's dominant agricultural industry. It is also likely that the acute national awareness of water issues plays into these discussions, and is, at least in part, an effort by those stakeholders trying to steer these narratives so as to attempt to broaden their coalition by appealing to this awareness, and to the significance of access to water in the collective national psyche (see appendix vi).

7.1.5. Dynamics and coalitions

It was noticeable that among stakeholders broadly opposed to gas, how diverse the range of their apparent motivations were for what they were against. One notable coalition / disconnection between the stakeholder groups was that of the environmental and labour movements. Both groups had positions rooted in the concepts of justice, and their divergent framing was not simply based on the "classic battles" (Janzwood and Millar, 2022 p. 2) between economics and environment. Rather, it seems, these tensions are a reflection of the range of components that are influencing RSA's energy landscape:

> "The notion of a 'transition' has a specific meaning and history in South Africa. Because of the history of apartheid, South Africans are acutely aware that transitions are deeply political, involve struggle against powerful and deeply entrenched interests, and take years if not decades to bring about" (Swilling and Annecke, 2012).

That individuals come together into coalitions that represent their ideological preferences, geographical situation, or historic allegiances, is unsurprising, but is perhaps particularly relevant in this context. The relative influence of these groups, however, is significant. South Africa's energy landscape is monopolised (Andreoni et al., 2022), and the new elites and the minerals-energy complex are largely a reflection of the apartheid-era order (Baker et al., 2014; Lawrence, 2020), and of how the unions are politically connected to upper echelons of the ANC (see section 4.2). It is also a consideration that the power of fossil capital limits the strategic frames other stakeholders can adopt (particularly within the labour movement) (Carroll, 2021; Janzwood and Millar, 2022).

As a standalone conclusion, it may be worth remembering by anyone seeking to initiate a paradigm shift based on concepts of justice that "something often seems impossible until it's done" (Nelson Rolihlahla Mandela).

7.2. Research question 2

How does geoscientific knowledge feature in government narratives? Are these framings integrated within wider socio-political and socio-economic debates?

7.2.1. The politics of possibility

The use of speculative shale gas resource estimates as a means of resource-making were addressed in Paper 2. In the South African context, the initial resource-making groundwork was laid down by external actors, namely the EIA, and because of this it seems likely that the main aim of resource-making framings of indigenous gas resources by the ANC is not primarily to generate "hype" in its shale gas resources, such as was the case in Mexico's Burgos Basin outlined by Fry and Murphy (2021 p. 2). To maintain these initial resource-making framings, the ANC, and its subsidiaries, needed only to ensure their sustained exposure, an objective, as was argued in Paper 2, achieved through the re-evaluating of existing data by state entities (Kuchler and Bridge, 2023; Weszkalnys, 2015). That the ANC did not need to generate this external interest[52] is demonstrated by Shell's established interest in the resource (see appendix i). However, Shell, together with other multinational petrochemical companies, have withdrawn from South Africa, or were "chased out", as Mr Mantashe puts it (section 4.5.2),

[52] In this context, I am referring only to interest in the primary source, not its derivatives such as tradeable concessions (see Paper 2).

which is where, I propose, resource estimates and resource-making reemerge as relevant to this discussion.

Paper 2 identifies the potentially mutually-beneficial value (political and economic) of maintaining these high-end resource estimates to both the DMRE and PASA (section 5.5.4). It seems to follow that "gestures" (Kuchler and Bridge, 2023; Weszkalnys, 2017) such as PASA's re-evaluating the EIA shale estimates, were essentially performative within the broad governmental geo-imaginary framing. These gestures, however, may well serve a secondary purpose.

The ANC installed President Ramaphosa in 2018, and has since sought to distance itself from the previous tenure of President Zuma, which had become mired in allegations of corruption and state-capture (Krige, 2019). The ANC, therefore, may be trying to re-establish themselves as "open for business" on the international stage. Kuchler (2017) introduces Foucault's concept of *governmentality* as an epistemic lens through which to explore sociotechnical imaginaries, and when viewed through this "micro-political analytic[al]" lens (Lövbrand and Stripple, 2015 p.95), the ANC's resource-making gestures acquire a more nuanced complexion. If the ANC are to encourage re-engagement with international petrochemical organisations, they need to address the reasons for the reluctance of these bodies to operate in RSA, (which, it is clear, has little to do with resource estimates (Paper 3)). The exact reasons for Shell's withdrawal are impossible to establish, but the political, legislative, and regulatory situation (see Paper 1), alongside the economic approach adopted by the ANC, were identified in the interview process as the likely causes:

> "I've heard nothing about Shell coming back and looking at the main Karoo basin, as I say, they were frightened off by the regulations, the 20% free carry was a no-no, it made it unviable to spend all that money and then have to potentially give up 20 percent of your profits to the government for nothing" (Participant 12)

Mr Mantashe's actions (or gestures) therefore, may be instructive. According to Foucault (1982 p. 93), governmentality involves the imagining of futures as a "complex strategic situation", and one in which apparently mundane actions predicate further action (Kuchler, 2017; Miller and Rose, 2008). Mr Mantashe is publicly promoting shale gas resource development, and distancing the ANC from "chasing" Shell out of RSA. He is, moreover, establishing institutional alignment with his pro-shale objectives: what I referred to as gestures (see Paper 2). That Mantashe is able to influence subsidiary agencies is a reflection of the ANC's top-down governance structure, and of his situation at the "top" which raises the question of who Mr Mantashe actually needs to convince, in order to establish his preferred energy policy. The answer to which, I would argue, is the ANC itself: which brings us back to shale gas resource estimates, and to resource-making.

It seems that the petrochemical multinationals are not in practice much influenced by the latest resource estimate appraisals published by the ANC (or PASA or the CGS). The KDDP has been mobilised for over five years, at considerable expense (see section 6.5.4), and has produced a small array of boreholes with only limited demonstrable empirical value (see papers 1, 2, 3). It is likely, therefore, that resource estimates, and the resource-making gestures orchestrated by Mr Mantashe, are primarily designed to establish a consensus within the ANC, and provide its Executive Committee with justification for its policy-decisions, and these justifications are primarily a suite of geo- and socio-technical imaginaries.

This micro-political analysis, based on my own interpretations, is inevitably provisional. But, Kuchler (2017 p. 34) argues:

> "It is in discourse that power and knowledge are joined together, by shedding light on this reciprocal effect of the knowledge-power relationship, the governmentality approach asks not only about what makes this conjunction necessary but especially about how it is deployed in practice [...] In other words, Foucault's analytics of government lets us expose linkages between the production of knowledge – *e.g.* speculative apparatuses of describing, estimating, and appraising to let us know the potential of a given geological resource – and ways of acting upon this knowable resource by prescribing its future potential in different forms of administering, regulating and strategizing".

It is this that I have attempted to achieve. By providing a specific example of a political deployment of resource estimates, and an appraisal of its framing, as well as practical application, and associated political "strategizing", it is hoped that new insights have emerged. The practical application of theory is, of course, problematic: there is always more that could be said, and caveats at every turn. Nevertheless, this attempt sheds at least some light on an evolving, complex problem.

The political power of the politics of possibility is identified by Kuchler and Bridge (2023), and addressed in Paper 3. When applied in the South African context, there emerge some interesting findings. It has been argued that the ANC are cultivating a geo-imaginary of "resource abundance" (Kuchler, 2017), which it might seem a bit counterintuitive for a political party that have been in power for thirty years, and are currently embroiled in an energy crisis elevated to the status of national state of emergency. However, as discussed in section 4.6, in maintaining the abundance framing, and conflating this with concepts of injustice, the ANC are managing to construct a narrative in which they are not responsible for the dire state of the of the energy system, but are in fact the victim of “nefarious” (Mantashe – SAOGA, 2023) actors:

> “Many of the non-governmental organisations that take us to court have unlimited resources, they are funded by foreign entities. When a non-governmental organisation is funded by a Ford Foundation, or by a number of those entities in the United States, you can’t rule out the fact that some of it comes from the CIA and a deliberate programme to block development in a poor country like South Africa” (Mantashe – SAOGA, 2023).

Thus, in discussing Shell’s proposed offshore development, Mantashe observed:

> “"We consider the objections to these developments as apartheid and colonialism of a special type, masqueraded as a great interest for environmental protection" (Mantashe, 2021).

In this framing, it is argued that the ANC are presenting themselves as the bulwark against the nation backsliding into the racially oppressive regimes that have dominated their recent history. These are obviously powerful framings, but it could be argued, they are constructed, at least in part, on speculative resource estimates.

The government’s failure to integrate externally-derived geoscientific knowledge is also relevant when viewed as a component of a wider socio-political narrative. That de Kock et al.’s (2017) report was largely ignored, despite its not unfavourable conclusions, is instructive. Kuchler and Bridge (2023 p. 9) argue that:

> “Uncertainty and indeterminacy are constitutive and generative of forms of socio-political order, rather than merely a residual or excessive element evading efforts at control”.

That the conclusions of de Kock et al, (2017), and the resource assumptions of the SGDCK are broadly aligned, would seem to present a reasonable, evidence-based basis for pursuing shale gas resource development in the Karoo. But the geoscientific and socio-economic findings of these publications would necessarily remove a degree of this uncertainty. To this end, that the government and its agencies did their best to ignore the de Kock et al. (2017) estimate (Paper 2), may be a reflection of their preference in maintaining the present uncertainty and indeterminacy. If this is the case, then their unwillingness to integrate knowledge grounded on more scientific evidence-based approach, becomes more rational. Finally, the fact that external appraisals of geoscientific knowledge are by definition beyond their control, may shape the ANC’s broader socio-political strategy, and contribute to their omission from the government narrative.

7.3. Research question 3

What changes to existing groundwater governance arrangements are needed in South Africa to mitigate the potentially deleterious consequences to groundwater resources of shale gas development?

7.3.1. Introduction: Common-pool resources and shale gas resource development

The third question outlined in the introduction of this thesis connects the common-pool resource literature with shale gas development and its governance. This is by no means a novel approach (see *e.g.* Corrigan and Murtazashvili, 2015; Murtazashvili and Piano, 2018; Laurens et al., 2019), but many aspects of the CPR literature that are underrepresented in academic literature could be of value to the shale gas debate, both in informing the decision-making processes prior to shale development, and in contributing to its effective governance during the extractive and decommissioning phases.

Although shales, and their potential gas resources, are not obviously commons material, as are, for example, forestries or fisheries, shales, and particularly the externalities (*e.g.* groundwater) associated with shale gas development, nevertheless embody many characteristics of the commons (Corrigan and Murtazashvili, 2015). Moreover, the common-pool issues associated with conventional gas extraction, notably those of propriety and utilisation, have established (if imperfectly) industry mechanisms to deal with them (Libecap and Smith, 1999), although mechanisms which address common-pool externalities are not so far well-established in the shale gas industry. The reasons for this are numerous, but notable factors include the relatively recent technological developments which facilitate large-scale shale gas extraction, the *ad hoc* nature of the industry's development, something compounded by the disparate legal and regulatory frameworks in the US (Wiseman, 2014), and that the costs of addressing externalities are often met, if at all, by non-industry bodies (Barth, 2013). Addressing these challenges, therefore, requires different institutional solutions (Corrigan and Murtazashvili, 2015), and it follows that a CPR appraisal of shale gas resource development and its externalities will augment the existing literature.

To test the usefulness of CPR theory in addressing the challenges of shale resource development in South Africa, examining the groundwater governance arrangements in the country could be expected to achieve two objectives. First, it will directly address an important externality associated with shale gas development. Second, interrogating the governance arrangements of groundwater allows a detailed exploration of existing arrangements, the findings of which can then be applied to shale gas development issues. That there is already correspondence between the governance of the two resources (*e.g.* institutional, regulatory, scientific) lends supports to this approach.

7.3.2. Key themes

The key themes outlined in Paper 3 provide a framework to address this research question. Its development came out of the CPR literature, and the categorisations provide an opportunity for comparison between the two resources.

7.3.2.1. Actors

What became apparent early in this research, and was summarised in Paper 3, is that RSA primarily practises a top-down mode of governance. Policies, legislation, rights, and obligations are prescribed and enforced by national-level central government. It was also the case that central government has regularly been criticised for a lack of transparency, and a for lack of inclusivity (in an institutional context) in its decision-making processes. This is of relevance to shale gas development. Transparency is essential in resource policy development because it positively impacts on economic development, government effectiveness, and regulation quality (Corrigan, 2014; Williams, 2011), and will also positively impact on issues underpinning both the resource curse and corruption (Corrigan, 2014; Kolstad and Wiig, 2009; Williams, 2011). Moreover, transparency has already been identified as a fundamental aspect of the just energy transition (Paper 1) (Becker et al., 2019; Carley and Konisky, 2020). The exclusion of certain groups from the decision-making process is also a matter of concern, and since RSA government is under significant financial pressure, by limiting external institutional input, they are limiting access to both expertise and financial investment. External input, of course, needs also to be subject to increased transparency (Marais et al., 2017).

Paper 3 also identified the polarised nature of the shale debate. Efforts have been made to address this issue, notably in the establishment of the SGSCK which involved a diverse range of stakeholders facilitated meaningful dialogue among them, and produced a detailed and generally well-received report. Two aspects of this report are relevant to this discussion. First, this research identified that the primary driving forces behind the establishment of the assessment panel were non-governmental actors, as the government were initially reluctant to engage in an open process of this nature. Second, throughout the course of this research project, and particularly in the combined document analyses, it became apparent that the

SGSCK report has largely been ignored. This seems to bear out the findings of this research (Papers 1 and 3), that where expert opinion goes against government policy, it is rejected: a cherry-picking among experts which has been identified as a source of public mistrust (Kama, 2019). It also exemplifies the uneven influence of stakeholder groups within the shale debate, identified in Ostrom’s (2006) social-ecological systems framework as influential on the outcomes of governance processes, and it is relevant to the knowledge generation aspects of this research, as it provides a context to what Latour (1990) describes as the “centres of calculation”, that is, which actors are involved in knowledge creation, and which are excluded.

Stakeholder engagement processes involved in shale gas development are discussed at several points in this thesis. That these processes are constitutionally required was found to be useful in building trust, and in embedding inclusivity into government actions, but, as identified in Paper 3, they do not necessarily translate into meaningful engagement, and instead are often seen as obligatory but perfunctory gestures: findings corroborated by Corrigan and Murtazashvili (2015), in their shale governance assessment.

7.3.2.2. Regulatory, legal and institutional frameworks

The legal framework in South Africa is well-regarded in the academic literature, which was apparent throughout the course of this research, but there were two aspects of the legislative framework that were of note to shale gas development. The first was that of legislative primacy, notably between NEMA, and the MPRDA (see figure 3.2). Although in Paper 3 I noted that the social and environmental provisions within NEMA, and the supporting provisions embedded in the Constitution, are supposed to precede mining, this is a matter of interpretation. Such judgements are interpretive, but could potentially come to play a future role in shale gas policy, such as happened in the US with the establishment of the Energy Policy Act (2005), and its so-called “Halliburton loophole”, which exempted certain industrial activity from environmental laws (Laurens et al., 2019).

Second, the unresolved land ownership debate about the Expropriation Bill and its proposed amendment of expropriation without compensation, is potentially a source of conflict should large-scale shale gas extraction ever materialise. These unresolved issues are a matter of contested public opinion, and it has been suggested that their adequate resolution has at least in-part been impeded by unresponsive, top-down government policy (Akinola, 2020; Mubecua and Mlambo, 2020). My conclusion is that a dramatic change in land-use would not do much to simplify these complex moral and legal debates. And on legal property rights and shale resources as a CPR, it has been suggested that disputes over land ownership could generate an “anticommons” scenario: that is to say that if two commons are in competition (*i.e.* land and gas), and one establishes precedence, the outcome might well be socially undesirable (Leonard and Parker, 2017).

One final observation on the legislative aspect of the shale debate in South Africa is that it has been a litigious process to-date (see section 4.2), and given Mr. Mantashe’s explicitly combative position (see section 4.5), this trend can be expected to continue.

The regulatory framework regarding both shale gas development and its impact on groundwater has been found to be incomplete (see Esterhuyse et al., 2022). This was identified by the SGDCK in 2016, and remains relevant, in part because the time it takes to establish regulations, and the insubstantial content of draft regulations, were regularly observed as a concern throughout this research. Although regulatory jurisdiction of governmental departments has been amended (see section 6.5.2.2) to address concerns of impartiality, it remains to be seen whether they are suitably aligned to what’s needed should shale gas development happen. Ostrom (2008) outlined the need for commons to have clearly defined boundaries, with corresponding regulatory arrangements, but the atypical nature of this commons example, and its focus on externalities, complicates an already difficult task. One solution which has been proposed to address this would be to reduce the number of government actors, and to extend the authority of those remaining (Wiseman, 2014). The arguments for this approach, however, while theoretically logical from a CPR perspective, don’t appear to be practical.

If boundaries are to remain undefined, and corresponding regulatory authorities impracticable, as is reasonable to assume, then other approaches to governance are required, and some form of polycentric governance is needed (Pietersen et al., 2016; Seward and Xu, 2018).[53] However, this research identified challenges in effectively implementing such processes. To manage shale gas development, there needs to be an ecosystem of institutions, and institutional gaps in this respect were highlighted in Paper 3. Other challenges include the persistent underfunding of institutions, which limits their functional capacity, which is particularly prevalent at the local level. Institutional capacity is a prerequisite for poly-centric governance models to operate efficiently (Murtazashvili and Piano, 2018), and unless this is addressed, which seems unlikely, theoretical governance models remain academic. The other notable barrier for an effective poly-centric governance model is the apparent lack of effective

[53] An interactive governance model that can facilitate effective stakeholder interconnections both vertically through institutional levels (e.g. between local government, central government and supranational institutions) but also horizontally between stakeholders at the same institutional level thereby improving the transmission of information, and effectiveness of institutional response (Cash et al., 2006; Ostrom, 2010).

communication channels between institutions and government departments, which are, again, a prerequisite for effective implementation (Paper 3), (Murtazashvili and Piano, 2018). This research identified several *ad hoc* communication channels, but although these may be effective, their reliance on inter-personal relationships means they are far from robust. This is further compounded by the institutional amnesia identified in Paper 3. Established mechanisms of inter-departmental and institutional coordination need therefore to be prioritised, as they have been identified as an effective, low-cost method of improving regulatory outcomes (Laurens et al., 2019; Murtazashvili and Piano, 2018).

Regulatory independence was identified as a matter of note. PASA's role in the shale gas development process was identified as inconsistent with its function as an independent regulator. PASA were identified in Paper 2 as influential in the generation and promotion of speculative resource estimates, and their governance was found to be lacking in transparency. Should the ANC or its members become shareholders in shale extraction projects, as appeared to be likely according to Legal Brief (2012), this would create an obvious conflict of interest.

Finally, the GWG review identified persistent non-compliance with existing water regulations. This, although not in itself a definitive argument, raises concerns of non-compliance in other sectors.

7.3.2.3. Policy

Formal policy addressing shale gas development and the identified externalities is notable by its absence, which was identified as a result of ineffective leadership and burdensome bureaucratic processes (Paper 3). There was also evidence that the government is reluctant to commit to a policy (*e.g.* the repeated delays in either updating or replacing the IRP). So, in the absence of a coherent policy approach, there has emerged a patchwork of formal and informal policies, described as "uncoordinated and haphazard" (Yelland, 2021 p. 3), that was found to be ill-suited to navigating the complex socio-economic and socio-ecological challenges posed by shale gas development. This uncoordinated approach was described as an "unhealthy environment" (Paper 3), in which to undertake the substantial work needed to address issues of preparedness for shale gas resource development.

This identified policy vacuum, and its inherent uncertainty, have become fertile ground for the broad geo-imaginaries identified in Paper 2. Although there is no suggestion that this scenario is created by design, there is evidence to suggest that the ANC is exploiting its own failure to produce formal policy for political advantage. It seems that this uncertainty, and subsequent speculation, create a feedback loop which is unhelpful in generating much-needed and coherent formal energy policies.

It emerged that there is broad consensus that the government needs to adopt a data-driven approach to energy policy, and that a data-driven approach should include inter-disciplinary data, such as that generated by the various stakeholders of the PCC; and that justice principles must also be incorporated into the policy framework. But, as was observed earlier in this discussion, the existence of stakeholder engagement vehicles such as the PCC, does not necessarily translate into their incorporation in policy. But it is clear from the findings of this research that there is an active and engaged citizenry, supported by a diverse range of institutional stakeholders, pushing for these principles to be adopted, so there is a prospect that top-down governance approach will not necessarily impede their success.

One notable development regarding data-driven policy observed during the course of this research was the evolution of the NBI's assessment of the role of gas in RSA's future energy mix. Although still promoting gas as a necessary component of the mid-term energy mix, their economic and technical assessments shifted away from developing indigenous gas reserves (Paper 1) as an optimal policy pathway, highlighting the increasingly isolated position the ANC finds itself in on its indigenous gas policy.

7.3.2.4. Knowledge, information and science

The methods of geoscientific knowledge production have been discussed throughout this thesis (Paper 2), as have the key actors involved in its development, and their relative influence on the shape of Latour's (1990) "centres of calculation". But the key findings that emerged from this element of the research, and which address this research question, are to do with information and science.

Baseline monitoring was frequently identified as a prerequisite for the preparedness of shale gas resource development, and this research found that an effective groundwater monitoring network had been established, so its maintenance and continued independence should be prioritised. By extension, it is also proposed that efforts need to be made to establish more detailed quantitative baseline indicators regarding socio-economic and socio-scientific indicators, such as regional income distribution, and health data, against which future developments can be assessed.

As identified in papers 2 and 3, the lack of transparency in the scientific methodologies and data from both the CGS and PASA limits the usefulness of its acquisition. That the methodologies underpinning agency shale resource estimations are restricted is unhelpful from a scientific perspective, but instructive when viewed through a critical resource geographies lens (Paper 2). The concepts of information sharing, and of a "knowledge commons" (Frischmann et al., 2014; Hess and Ostrom, 2007) have been recognised as a means of improving the value of data for the common good. Wiseman (2014) observed that a somewhat naïve understanding of the proprietorial aspects of geo-scientific data is behind this position, but nonetheless, it remains important.

It seems that the data acquired throughout the shale research processes in RSA could be of considerable scientific and technical benefit to the nation, and because of this it should be in the public domain:

> "The optimal approach would be to take the first exploratory steps cooperatively, and in the public-domain, rather than in a competitive, secretive and proprietary way. This would allow South Africa to learn about the deep geology of the Karoo and the technologies and hazards of deep drilling, even if no viable gas was found" (Paper 2).

7.3.3. Common-pool resource conclusion

The lessons learned from the CPR literature provided a useful framework to approach this research question. From a methodological perspective, looking at institutional mapping, actors, and governance systems, together with their interactions and their collective influence on outcomes, all produced useful insights, as well as a solid foundation from which to begin primary data collection. Analysis of groundwater governance to address both a specific commons externality associated with shale gas resource development, and as a means of assessing broader governance arrangements about this, was productive. That groundwater is in fact already being governed made possible a more detailed appraisal of existing governance arrangements than would have been possible had the focus of this aspect of the research been limited to shale only. Although some of the findings are then proxy extrapolations, the considerable overlap of governing the two resources, made this process instructive.

7.4. Recommendations for future research

In this thesis I have been interested in a range of aspects of South Africa's energy landscape, and in how these various elements are situated in different theoretical frames. One particular subject of interest, identified across all of these varying approaches, though largely ignored within them, was that of the spatial geographies in South Africa's energy debate. Much of the literature that influenced this research identified the importance of local realities, which was instructive in my national-scale approach to the work. But the local-level realities in South

Africa, influenced as they are by the apartheid legacy, and by the geographies of past and present resource-extraction and production, are significant. These spatial aspects will be crucial in South Africa's energy transition, regardless of its trajectory, and of how the concepts of justice, briefly outlined in this research, work out. Much of this research, and other work addressing energy issues in RSA, either homogenises the issue, or focusses purely on the local-level. Integrating these two levels of governance will be crucial, and research facilitating that integration, and providing context to what are so often referred to, both within this thesis and by others, as "trade-offs", will be a useful, and potentially powerful tool, in the transition debate.

The integration of the common-pool resource literature, particularly that of groundwater governance, with gas resource development issues, has proved an instructive way of addressing complex socio-ecological governance challenges. It seems that a continuous integration of the key themes of actors, of legal, institutional, and regulatory frameworks, together with those of policies, of knowledge, information, and science, all of them touched on in this research, will be a useful means of facilitating practical, beneficial, solutions should shale gas resource development emerge as a likely short-term scenario.

7.5. Concluding remarks

Since starting my PhD in 2018, the global energy landscape has undergone radical shifts that have changed the whole nature of my research. First, COVID-19 hammered the oil industry, which plunged US crude into negative value for the first time in history, in April 2020. And, second, Russia's invasion of Ukraine spiked gas prices to levels not seen since the 2000s energy crisis. This financial upheaval inevitably took its toll on the global energy markets, and raised questions about the sustainability and vulnerability of the global energy system, though the most relevant impacts on this research were geopolitical. The soaring gas prices brought national energy security into sharp relief, and the framing of gas (and alternative energy sources) in South Africa inevitably shifted. Further, the energy crisis also led to European countries aggressively to seek to secure long-term supply contracts with Arican nations, to rejuvenate stalled discussions on gas development projects, and to declare gas investments as green. All this remains influential in the energy transition debate, but as has been shown, it also feeds into some of the more fraught elements of the national energy dialogue regarding issues of colonialism, apartheid, and justice.

The increased focus on energy security has led to more research addressing this issue and its externalities, which, alongside dealing with a dynamic, specific, socio-political energy scenario, has made my research project at once fascinating and dauntingly challenging. A focus on framing and data analysis meant that the data-collection phase of the research could never really be complete. Even where I outlined specific frames of reference, for example the Presidential Climate Committee, the dynamics had changed before the ink had time to dry. Despite this, it is to be hoped that this thesis will shed light on a complex issue, that it will have some value both to the academy, and to the evolving theoretical discussions addressed in it, but also to the broad range of stakeholders with an interest in this ongoing debate. Finally, whatever its immediate value, this thesis can be expected to be useful as an archival document which recorded processes and issues of a specific time, in a pivotal period, in the evolving energy situation in South Africa.

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Appendix

i) An historical timeline of unconventional oil and gas extraction and fracking studies in South Africa

Date	Event
1940	The first organised search for hydrocarbons in South Africa is undertaken by the Geological Survey of South Africa (PASA 2023).
1965	The Southern Oil Exploration Corporation (SOEKOR) is formed with the mandate to identify the existence of economic volumes of oil and gas in South Africa.
1972	Exploration drilling indicates the presence of (at that time economically unrecoverable) gas within the Ecca shales (Rowsell & De Swardt 1976).
1976	The Council for Geoscience (CGS) investigates the oilshale potential of the Whitehill Formation on the western flank of the Karoo Basin. They drill 16 core boreholes in the area between Strydenburg and Hertzogville. This study, together with all available borehole logs and cores over the whole extent of the Whitehill Formation, and that intersected the Whitehill

	Formation, form the basis of the majority of shale gas resource estimates for the Karoo that have been made to date (Hobbs *et al*. 2016)
1968	Soekor finds promising oil & gas reserves in Soekor borehole CK1/68 in the Eastern Cape (James 2016)
2009-2010	The Petroleum Agency of South Africa (PASA) grants technical cooperation permits to Falcon Oil and Gas, Shell B.V. International and Sasol-Chesapeake-Statoil consortium to conduct an assessment (PASA 2019)
December 2010	Shell submits exploration licence applications (de Wit 2011)
2011	The US Energy Department estimates that the Karoo basin has 485 trillion cubic feet (Tcf) of Technically Recoverable gas (USEIA 2011)
February 2011	Activist groups are mobilised and the Treasure the Karoo Action Group (TKAG) is established (TKAG 2020)
April 2011	The moratorium on oil and gas exploration in South Africa is instated (Hedden *et al*. 2013)
Feb-July 2011	Lobbying of activist groups against shale gas continues to intensify, fuelled by media debates (Hedden *et al*. 2013)
July 2011	De Wit comments on the great shale debate in the Karoo and calls for centres of excellence where the effect of UOG energy development can be properly investigated (de Wit 2011)
11 November 2011	The South African government releases the National Development Plan, stating that shale gas could contribute to electricity generation in South Africa (NPC 2011)
July 2012	The Department of Mineral Resources releases the Report on the investigation of hydraulic fracturing in the Karoo basin of South Africa (DMR 2012)
November 2012	The South African Water Research Commission launches the study entitled 'Development of an Interactive Vulnerability Map and Monitoring Framework to Assess the Potential Environmental Impact of Unconventional Oil and Gas Extraction by Means of Hydraulic Fracturing' (Esterhuyse *et al*. 2014). This study assesses the impact of UOG on the South African biophysical and socio-economic environment and South Africa's vulnerability to fracking.
2012	The Petroleum Agency of South Africa (PASA) provides an estimate of the potential Karoo basin shale gas resource to assess the reliability of the US Energy Department's 2011 estimate (Burns *et al*. 2016)
September 2012	The cabinet lifts the moratorium on oil and gas exploration and recommends that regulations be drafted to protect the environment (RSA 2019)
June 2013	EIA revised their volumetric estimate of Technically Recoverable gas down from 485 to 390 Tcf stating, "reduced area due to igneous intrusions" EIA (2013) pp. 1-9

July 2013	Given impending fracking regulations that are to be published, Esterhuyse *et al*. (2013) publishes a study on the knowledge base and opinions of decision-makers on the regulation and monitoring of unconventional gas mining in South Africa
15 October 2013	The draft technical regulations on hydraulic fracturing 'the fracking regulations' is published (RSA 2013)
December 2013	The Centre for Environmental Rights, academia and other stakeholders comment on the draft fracking regulations, view it as inadequate to protect natural resources and call for the drafting of regulations that would do so (CER 2014)
October 2014	The Water Research Commission study entitled 'Development of an Interactive Vulnerability Map and Monitoring Framework to Assess the Potential Environmental Impact of Unconventional Oil and Gas Extraction by Means of Hydraulic Fracturing' (Esterhuyse *et al*. 2014) is published. This study finds the impacts of Karoo fracking to be regional and cumulative and recommends a Strategic Environmental Assessment of shale gas extraction in the Karoo.
December 2014	The knowledge of unconventional gas mining among decision-makers in South Africa is again evaluated and researchers implore policy-makers to pursue fact-based water policy development (Esterhuyse & Redelinghuys 2014)
8 December 2014	Instatement of the 'One Environmental System' (DEA 2019)
February 2015	The Strategic environmental assessment (SEA) of shale gas in the Karoo is commissioned by the Department of Environmental Affairs (Scholes 2016)
3 June 2015	The final 'fracking regulations' is promulgated by the Minister of Mineral Resources under Regulation R.466 in Government Gazette No 3855 dated 3 June 2015 (RSA 2015a)
16 October 2015	The Department of Water and Sanitation declares the 'Exploration and or production of onshore naturally occurring hydrocarbons that requires stimulation, including but not limited to hydraulic fracturing and or underground coal gasification, to extract, and any activity incidental thereto that may impact detrimentally on the water resource' as a controlled activity (RSA 2015b)
November 2015	Stern and others apply to the Eastern Cape High Court and TKAG and Afriforum apply to the Pretoria High Court to set aside the fracking regulations (RSA 2019a)
July 2016	Rhino oil applies for UOG exploration in the Drakensberg and Free State with application ER294 (SAHRA 2023a)
November 2016	The SEA on Karoo shale gas is completed (Scholes 2016)
2016	CGS as per instruction from DME initiates the Karoo Deep Drilling project (KDD) to investigate the potential resources in the Karoo basin outlined by the EIA. (Global Africa Network, 2020)

2016	A book that considers both the legal and environmental perspectives of fracking in the Karoo, is published (Glazewski & Esterhuyse 2016).
June 2017	A study by de Kock *et al*. (2017) estimates that significantly fewer shale gas resources may be available for exploitation, at approximately 13 Tcf, compared to the 485 Tcf that was estimated to be available by the USEIA (2011).
17 October 2017	The Eastern Cape High Court sets the DMR 'fracking regulations' aside in the case of *John Douglas Stern and Others v the Minister of Mineral Resources* (RSA 2017)
16 May 2018	The Pretoria High Court dismisses the TKAG and Afriforum applications to set aside the fracking regulations in the case of *Treasure the Karoo Action Group and Another vs the Department of Mineral Resources and Others* (RSA 2018)
April 2018	Shell withdraws South African onshore fracking plans (*Engineering News* 2018)
2018	PASA's internal estimate for shale gas inside the Karoo basin is revised to be 205 Tcf (Petroleum Agency SA, 2018)
4 July 2019	The Supreme Court of Appeal sets aside the fracking regulations in its entirety. The court also indicated that the commencement of any UOG extraction activities should not be allowed before regulations to protect natural resources are in place (RSA 2019a)
October 2019	IRP for 2019 is published, "indigenous gas like coal-bed methane and ultimately shale gas, could form a central part of our strategy for regional economic integration within SADC" (IRP, 2019)
24 December 2019	The Draft upstream petroleum resources development bill is published (RSA 2019b)
2015-2019	Various scientific case studies shed more light on shale gas resources and methane occurrences in the Karoo (Chere *et al*. 2017; Eymold *et al*. 2018; Geel *et al*. 2015; Hohne *et al*. 2019; Murray *et al*. 2015)At the same time, academic studies that focus on natural resource protection, assess impacts (Esterhuyse *et al*. 2016), and laboratory analyses capabilities for monitoring water pollution during UOG extraction (Mulovhedzi and Esterhuyse 2021), are completed. They make recommendations on natural resource monitoring (Esterhuyse *et al*. 2018), wastewater management (Williamson & Esterhuyse 2020), and the development of regulations to protect water resources during UOG extraction (Esterhuyse *et al*. 2022; Esterhuyse *et al*. 2019).
21 September 2020	The CGS announce Phase 2 of KDDP in Beaufort West. This phase involves CGS establishing a geo-environmental baseline and putting in place environmental monitoring mechanisms around the Karoo basin (M. Arnoldi, 2020). They begin drilling a 33,500 meter stratigraphic hole (Energy Voice 2021).

September 2020	Rhino oil applies for oil and gas exploration rights for petroleum on various farms in the Free-State and Kwazulu-Natal provinces via application 350 ER (SAHRA 2023b)
2020	PASA commissions the development of a regional groundwater monitoring network in the Karoo (*Engineering News* 2020)
May 2021	The KDD has drilled to a depth on 2,750 meters in the Karoo basin and have found 55 cubic meters of gas so far (Energy Voice, 2021)
2021	The Department of Water Affairs publishes draft regulations to protect water resources during UOG extraction for public comment (RSA 2021)
2021	Rhino Oil and gas applications in the Eastern Free State / Drakensberg region
February 2022	Rhino Oil withdraws ER246 exploration application for north-eastern Free State, Gauteng and Mpumalanga (Evans 2022)
July 2022	The Department of Forestry, Fisheries and the Environment (DFFE) publishes draft regulations to protect the environment (RSA 2022a) as well as minimum requirements for the submission of licenses during UO extraction for public comment (RSA 2022b)
April 2023	Rhino Oil submits amended EIAs for exploration permits ER318 (SLR 2023)
19 May 2023	Reuters quoted Petroleum Agency of South Africa (PASA) chief operating officer Bongani Sayidini as saying: “We are potentially looking at a minimum of about ten shale gas blocks in the Karoo that will be released through competitive bidding.” The first competitive auction for oil and gas resources in South Africa is anticipated to happen in 2024 or 2025 when legislation establishing the bid round is passed (2023i)

ii) Making Waves: How a water-resources crisis highlights social-ecological disconnects

Gittins, J.R., Hemingway, J.R., Dajka, J. How a water-resources crisis highlights social-ecological disconnects. *Water Research* (2021) https://doi.org/10.1016/j.watres.2021.116937

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A B S T R A C T

The sustainable management of water resources is required to avoid water scarcity becoming widespread. This article explores the potential application of a social-ecological framework, used predominantly in the fields of ecology and conservation, as a tool to improve the sustainability and resilience of water resources. The “red-loop green-loop” (RL-GL) model has previously been used to map both sustainable and unsustainable social-ecological feedbacks between ecosystems and their communities in countries such as Sweden and Jamaica. In this article, we demonstrate the novel application of the RL-GL framework to water resources management using the 2017/18 Cape Town water crisis as an example. We used the framework to analyse the social-ecological dynamics of pre-crisis and planned contingency scenarios.

We found that the water resources management system was almost solely reliant on a single, non-ecosystem form of infrastructure, the provincial dam system. As a prolonged drought

impacted this key water resource, resilience to resource collapse was shown to be low and a missing feedback between the water resource and the Cape Town community was highlighted. The collapse of water resources (“Day Zero”) was averted through a combination of government and community group led measures, incorporating both local ecosystem (green-loop) and non-local ecosystem (red-loop) forms of water resource management, and increased rainfall returning to the area. Additional disaster management plans proposed by the municipality included the tighter integration of red and green-loop water management approaches, which acted to foster a stronger connection between the Cape Town community and their water resources.

We advocate the wider development and application of the RL-GL model, theoretically and empirically, to investigate missing feedbacks between water resources and their communities.

Keywords: Water resources management, social-ecological, red-loop green-loop model, water crisis, feedbacks.

1. **A social-ecological framework for water resources management**

The sustainable management of water resources, globally, is required to avoid water scarcity becoming widespread. There are a number of human pressures (*e.g.* urbanisation, intensive agriculture, over-abstraction, inefficient distribution and exceptional demand) underpinning climate change, pollution and biodiversity loss that contributes to water scarcity (Eslamain and Eslamain, 2017). The idea that anthropogenic water systems can be resilient to the pressures of scarcity only through economic decision-making (*e.g.* cost-benefit analysis), engineering and technology is beginning to be undermined. Damming predictions (Boretti and Rosa, 2019) and real-world crises on many of the world’s continents seem to be increasing. We propose that civic water resource management could benefit from the application of a recently developed social-ecological framework, which highlights the importance of feedbacks between humans and ecosystems (Cumming *et al.*, 2014; Hamann *et al.*, 2015; Blythe *et al.*, 2017, Dajka *et al.*, 2020). This framework has not previously been applied within the realm of water resources management and may prove a useful tool in planning for better management and, ultimately, future resilience.

Social-ecological models have long been used in ecology and conservation research with the aim of improving habitat management (Scheffer *et al*., 2001). Cumming *et al.* (2014) proposed the red-loop green-loop (RL-GL) model which classifies social-ecological dynamics into red and green loops. These loops are based upon human dependence on, and interactions with, the local ecosystem, in addition to the sustainability of that ecosystem. Green-loop systems are defined by a sustainable relationship between a human population (often lower density) and their local ecosystem, such as a rural society practicing subsistence agriculture. Green-loop systems are reliant on ecosystem goods and services derived from their local ecosystem. Red-loop systems are characterised by the sustainable relationship between a human population (often higher density) and the local/regional socioeconomic system (often more metropolitan) they utilise to supply non-ecosystem goods and services. However, both green and red-loop systems can drift into unsustainable traps. Green traps are initiated by overconsumption and inadequate productivity, which if left unchecked can lead to rural poverty and ecological degradation which amplify each other, resulting in a green trap. At the other end of the spectrum, red traps can occur through overconsumption and the failure to manage ecological decline. Such ecological decline can progress unnoticed if the signal-response chain between the ecosystem and society is masked (*e.g.* missing feedback fostered by lack of ecological knowledge; Dajka *et al.,* 2020). Both traps can lead to ecosystem and resource degradation if the traps are not addressed (Cumming *et al*., 2014).

The RL-GL concept has been applied to a handful of national-level systems, including Sweden (Cumming et al. 2014) and Jamaica (Dajka et al. 2020). Sweden experienced a transition from green loop to red loop. For over 1000 years, the country had a low human population based on majorly agrarian lifestyles and was classified as a green loop system (Cumming et al. 2014). Accelerating population growth beginning in the mid-18th century, triggered a transition towards a red loop system at the latter end of the 19th century. Economic development, driven mostly by the industrial sector and growing export markets, fuelled the transition from the 1870s. Then, from 1950, the industrial and service sectors expanded whilst the agricultural sector remained largely stagnant. Swedish agricultural employment subsequently declined from close to a million in 1880 to less than 50,000 people in 2000. In a red loop system, disconnects between people and local ecosystems (missing feedbacks) and resulting environmental degradation are expected (Cumming et al. 2014). Great losses were beginning to be recorded in Swedish grassland biodiversity and old-growth forests in the 1950s. Further, overfishing in the Baltic Sea was recorded throughout the 1990s and still is today. Swedish imports and exports increased sevenfold between 1975 and 2000, with unknown impacts on external ecological systems. Many of the country's increased requirements were met by upscaling, with Sweden employing technological advances and modern farming methods that aided in reducing local environmental degradation whilst stabilising increased food production. Using this strategy, Sweden managed to retain a sustainable red loop system and not drift into an unsustainable red trap.

Jamaica on the other hand has moved through all RL-GL states (green loop, green trap, red loop, red trap) since the first human settlement around the year 600 until 2017 (Dajka et al.

2020). Here too, missing feedbacks between people and the local ecosystem were most detrimental to the Jamaican nearshore ecosystem. In contrast, it appears that the previously upscaled exports of locally caught reef fish are largely responsible for keeping Jamaica in a red trap scenario in recent years rather than a red loop as was the case for Sweden. More commitment to ecological monitoring and conservation appears to be the main difference between Jamaica's red trap state (Dajka et al. 2020) and Sweden's red loop state (Cumming et al. 2014).

The RL-GL model has not been used, however, to map the state of a nation's water resources, or to reveal any 'missing feedbacks' that may be driving management practices that are detrimental to a local ecosystem's ecological sustainability. Social-ecological approaches have only recently been seen as useful for water resources planning and forecasting (*e.g.e.g.* Jaeger *et al*., 2017), with the aim of improving the sustainable management of these systems. In this article we look to demonstrate application of the RL-GL model to analyse a water resources management system. We use the RL-GL model to identify functioning and missing social-ecological feedbacks across some specific management scenarios (real and hypothetical) of a single water resources system. As an example, we capture the water resources management of South Africa's Western Cape capital - Cape Town - and the water crisis of 2017/18. Using the RL-GL model enables us to provide an analysis of the human-environment relationships which defined the course of the Cape Town water crisis and highlight some of the dynamics which helped foster greater sustainability (Laurent, 2015).

2. An application of the red-loop green-loop model

The RL-GL framework provides a unique social-ecological lens through which to view the management of Cape Town's water resources management, preceding the implementation of emergency measures by the City of Cape Town (CCT) local municipal authority. However, first it is necessary to first provide some wider context of water resources management across South Africa and the Western Cape. The post-apartheid government of South Africa have introduced a number of policies designed to improve access to, and availability of, potable water, such as the Water Services Act (1997), and the Free Basic Water policy (2001). However, access to clean water, although greatly improved, remains a persistent problem (Muller, 2008). South Africa is a water scarce country (Cole *et al*., 2017), and a series of droughts in recent years have put pressure on the limited water resources. As a result, water scarcity became the focus of a major crisis, particularly for the Western Cape Water Supply System (WCWSS) which fed the province's major city, Cape Town.

In May 2017, water storage capacity at the WCWSS dams had reduced to around 20% (Climate Systems Analysis Group, 2019). This shortage resulted in the CCT triggering a disaster management plan that imposed a per capita limit of 50 litres (L) of water per day (Enqvist and Ziervogel, 2019; GreenCape, 2018), and warned that should storage drop below 13.5%, these limits would be reduced to 25 L (Enqvist and Ziervogel, 2019; GreenCape, 2018). This final action would be implemented by switching off municipal water supplies and installing communal distribution points to enable water rationing; an event that colloquially became known as “Day Zero” (CCT, 2017).

Several reasons have been identified for the water shortages that led to the crisis (Muller, 2017), notably: (i) a prolonged period of reduced rainfall; (ii) increased demand associated with population growth; (iii) the poor management of, and investment in, water management infrastructure; (iv) overallocation of water resources to the agricultural sector; (v) the overreliance on surface water; and, (vi) the spread of water intensive invasive vegetation (Parks *et al.*, 2019; Taing *et al.*, 2019). Similarly, there were a number of events and interventions that helped to mitigate the severity of the crisis: (i) a return of normal rainfall rates; (ii) supply augmentation via diversifying water-sources (*e.g.e.g.* increasing groundwater supply capacity); and, (iii) improvements in water recycling and distribution efficiency (Parks *et al*., 2019). These factors should be understood when considering the RL-GL concept application in South Africa.

Pre-crisis, the CCT municipality operated the distribution of clean water for public use (Fig. 1), sourced mainly from the WCWSS and as a quota allocated to the municipality by the nationwide Department of Water and Sanitation (Enqvist and Ziervogel, 2018). This consisted of typical piped infrastructure, engineered to distribute the water between the different consumer types (*e.g.e.g.* domestic or agricultural users) (Muller, 2019). Water levels in the WCWSS were monitored at the provincial level, though there was limited transparency between the national/provincial level and the municipal level, as well as the public. We argue that this lack of transparency produced a missing feedback (Fig. 1a). Within the predominantly red-loop relationship between water resources and the Cape Town community, a lack of transparency on the state of resources, and therefore, a lack of consumer behavioural change, further reinforced the disconnect and intensified resource depletion. Alongside this, the one-way, top-down governance of water supply management (*e.g.e.g.* the limited scope for negotiation between the CCT and the Department of Water and Sanitation for water allocation quotas) further reinforced the missing feedback between provincial catchment supply management and municipal authority quotas (Fig. 1a). Furthermore, reliance on a single supply water supply (*i.e.* the WCWSS) limits the options for water resource management to address drought resilience (Muller, 2018).

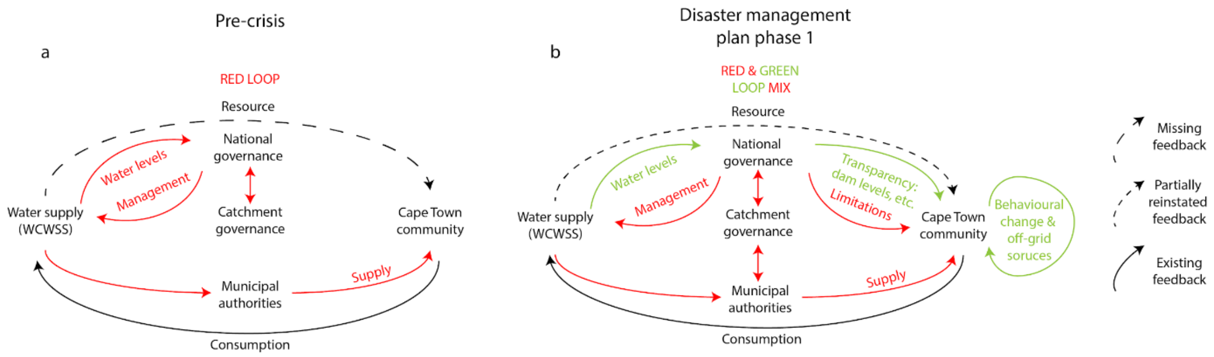

Figure 1. Outline of the management of the City of Cape Town's water resources, (a) prior to 2017 (*i.e.* pre-crisis), and (b) during phase 1 of the disaster management plan response to 2017-2018 crisis; WCWSS = Western Cape Water Supply System.

In late 2017, Phase I of the CCT's disaster management plan was implemented (Fig. 1b). This involved imposing water consumption restrictions to 87 L per capita per day (Taing *et al*. 2019) as well as the following additional actions: (i) improving the efficiency of the piped water distribution system; (ii) increasing the stepped pricing structure of additional water beyond the basic household allowance of 6000 L per month; and, (iii) organising and coordinating an Information, Education and Communication (IEC) campaign to improve the reporting and transparency of water-use and supply-based data to the municipal authorities and the public. These measures aimed to reduce water use by: (i) reducing leakage; (ii) changing consumption behaviour by making 'luxury' water costly, and; (iii) informing the public about the state of water resources. The IEC campaign specifically fostered a partial feedback between the consumer and the state of the water resources (Fig. 1b), bringing the interaction closer to a green-loop dynamic. Using data transparency such as 'The Big Six Monitor' (Climate System Analysis Group, 2019) and educational campaigns like "If it's yellow, let it mellow…" (Booysen et al., 2019). There was a resulting improvement in water use from these actions, with Booysen *et al.* (2019) reporting a per day household decrease of 48% throughout the duration of the crisis (2015-2018). Alongside this campaign to reduce water consumption and waste, the CCT also pursued supply augmentation policies (notably the large-scale abstraction of groundwater from three regional aquifers, and the expansion of both desalination and wastewater treatment capacity), further improving diversification and resilience (Taing *et al.*, 2019). This suite of measures adopted by the CCT demonstrates a successfully implemented combined red-loop green-loop approach to resource management.

The added transparency, and the consequent partially reinstated feedback, led many of the Cape Town community to change their behaviour. Some of these changes were positive, *e.g.e.g.* the steep reduction in personal water usage, and the supply augmentation policies adopted by CCT (notably the large-scale abstraction of groundwater from three regional aquifers, and the expansion of both desalination and wastewater treatment capacity) (Taing *et al.*, 2019). Other behavioural changes were also observed, notably a reported increase of people utilising new ‘off-grid’ sources of water, such as personal boreholes and small springs and streams to supplement or replace their local supply. Although these changes are not necessarily socially or environmentally positive (*e.g.e.g.* individuals having to travel to collect potentially unsafe water, or the use of unregulated boreholes), what they represent is a shift from what Simpson *et al.* (2020) describe as “dam mentality”. That is, people reassessing their perceptions of water security, and sought to look beyond the state supplied resource and its highly engineered network. It is argued that a transition away from a dam mentality coincided with behavioural change, partially reinstating the missing feedback between consumers (*i.e.* the Western Cape community) and the WCWSS (Fig. 1b). This behavioural change may also have initiated a new green-loop through the use of external (to the WCWSS) water sources. Unfortunately, however, this scenario likely resulted in further water inequality (Cole *et al*., 2017; Enqvist and Ziervogel, 2018).

Ultimately, Day Zero was avoided; normal rainfall in mid-2018 restored the water levels in the dams to a manageable level, but the in-crisis responses of the CCT and the Cape Town community also played a significant role in preventing a much more serious situation (Taing *et al.*, 2019). The course of the progressing crisis and implementation of phase 1 of the CCT’s disaster management plan illustrate how green-loops were increasingly integrated into the overall red-loop system as the crisis progressed. Next, we will discuss further (yet hypothetical) green-loop integration, as demonstrated by phases 2 and 3 of the disaster management plan which was proposed by the CCT to alleviate the crisis should the drought have continued.

3. Balancing social-ecological feedbacks to improve sustainability

The additional emergency strategy of phases 2 and 3 of the disaster management plan were agreed in advance to account for a continued period of little or no rainfall (Taing *et al.*, 2019). We interpret this additional emergency strategy using the RL-GL framework, to demonstrate how a mix of red and green-loops are employed to improve the sustainability of Cape Town’s water resources, and ultimately, the state of the ecosystem providing these water resources (Fig. 2).

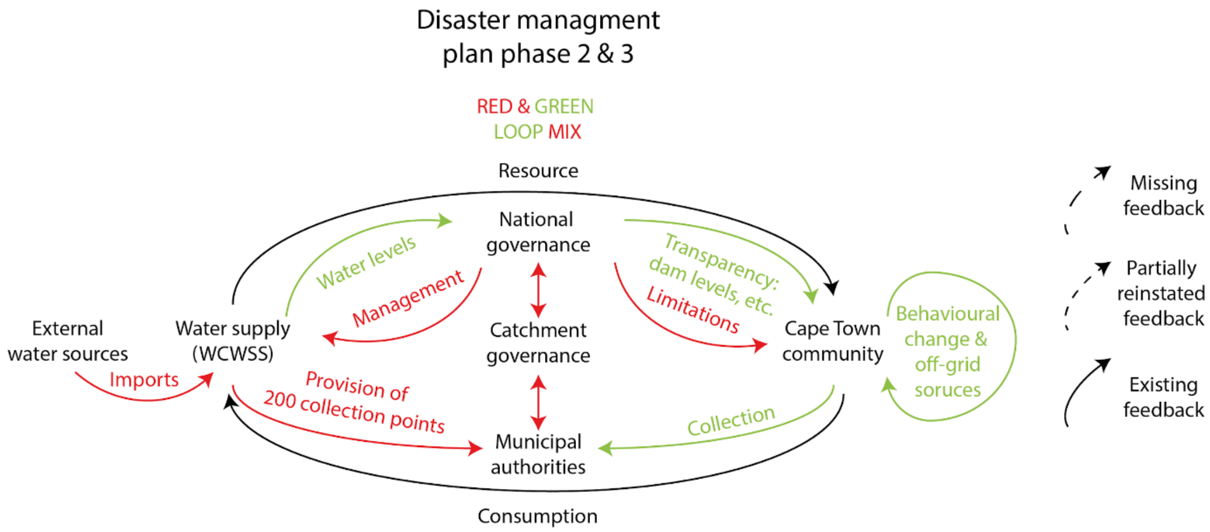

Figure 2. Outline of the management of the City of Cape Town's water resources phases 2 & 3 of the disaster management plan, contingency phases that were not employed in the 2018 water crisis.

The RL-GL framework highlights, that during phases 2 and 3 of the disaster management plan, knowledge of the state of water resources and the source ecosystem was transparent at a national level, for provincial Water Boards, the CCT municipality and the Cape Town community; this is demonstrated by a fully reinstated feedback between society and the water resource ecosystem (WCWSS). In phase 1 of the disaster management plan, this feedback began to be partially reinstated via an increasingly transparent flow of information about the state of the water supply (*e.g.* WCWSS dam levels), fostered through an IEC campaign and more general media coverage (Fig. 1b). In phases 2 and 3, the CCT municipality planned to organise 200 water collection points across the city which would integrate a new green-loop between the water resource and the Cape Town community (Fig. 2), that would be required to go to collection points and receive an allocated daily water provision of 25 L per capita (Taing *et al.*, 2019). The introduction of this new green-loop would likely have had implications for how Cape Town's community view their water resources, highlighting the severity of the scarcity and enforcing water collections. Although not a popular strategy, this may have fully reinstated the feedback (Fig. 2). Fortunately, this scenario was avoided as the IEC of this phase of the disaster management plan may have triggered environmentally conscious behavioural changes (Geng *et al.*, 2019), such as water-saving. Again, the Cape Town community seeking to avoid this scenario might also demonstrate a transition away from the typical dam mentality. The community adjusted their behaviour in accordance with a mixture of strategies aimed at increasing personal and public responsibility for water-use. Some attention has recently been given to explaining how a disconnect (in terms of human-nature interactions) between consumers and source ecosystems can result in unsustainable attitudes and behaviours towards the environment (Soga and Gaston, 2016; Dajka *et al.*, 2020); a dam mentality may be an example of this, at a personal or societal level. Others argue that a strong connection with natural ecosystems (and their resources) is beneficial for human health and wellbeing (Ives et al., 2017). Moreover, there is potential for re-connecting communities with nature in order to promote sustainable behavioural changes (Ives et al., 2018; Dajka *et al.*, 2020) and the improved management of water resources. Though, not at the risk of socially detrimental practices, as approaches to change behaviour for the benefit of sustainability *must* be balanced with improvements in technological efficiencies to not decrease standards of living.

Altogether, using the RL-GL framework to analyse the 2017/18 Cape Town crisis revealed that progressively integrating a typically red-loop system with more green-loops, helped to avert a deepening of the crisis (Fig. 1b). This balanced mix of loop types has the potential to improve the resilience of water resources and their management systems to crisis, and potentially facilitate adaptation over time to suit a changing climate. However, there is a need for more empirical research to complement the theoretical development of the RL-GL framework. This includes interdisciplinary experimental and statistical work to link specific feedbacks and ecological indicators to state policy or social interventions (*e.g.* Baudoin and Gittins, 2020), specifically related to the management of water resources. For instance, Cumming and von Cramon-Taubadel (2018) used a statistical modelling approach to connect the United Nations' Human Development Index (HDI) to the RL-GL framework. This research attempted to link the notion of red and green-loops to national development across a number of countries. The authors found 42 red-loop countries to be mostly HDI category 1 (very high development) and 32 green loop countries as mostly HDI category 4 (low development), with HDI 2 (high development) and 3 (medium development) being transitory phases of development in between predominantly red (HD 1) and green-loop (HDI 4) nations. In the most recent HDI assessment by the United Nations in 2018, South Africa was categorised as a HDI 2 country with a score of 0.705 (UN Human Development Report, 2019). Suggesting that indeed South Africa might be shifting from utilising both red and green-loop dynamics within its social-ecological system, towards a predominantly red-loop social-ecological system (*e.g.* HDI 1).

Although the HDI does not explicitly include the state of water resources in its assessment of a nation's development, it is fair to assume that good quality and well distributed water resources might be a feature underpinning some of the dimensions of the HDI (*e.g.* life expectancy, per capita income, education; UNDP 2019). Therefore, despite indicating a transition up the HDI, South Africa's score of 0.705 potentially indicates more intensive red-loop management of water resources nationwide. Viewing the Cape Town crisis through the RL-GL lens demonstrated how a solely red-loop managed system can lack resilience to external pressures (i.e. climate change). Other nations have, however, demonstrated that red-loop social-ecological systems can be sustainable; Sweden for example, as published by Cumming *et al*., 2014. Although, this is yet to be demonstrated for the management of water resources specifically. In the Cape Town example, the re-integration of green-loops into the system helped alleviate the crisis, and could potentially increase resource resilience by reinstating missing social-ecological feedbacks. It would be interesting to see if these findings are supported by other case studies, perhaps for the management of water resources in HDI category 1 and 4 countries. Additionally, analysing different water users (i.e. agriculture, industry) in the Cape Town scenario (or elsewhere) using the RL-GL model would be beneficial to gain a broader picture of the complex relationships between water supply and its consumers. To conclude, we strongly advocate the use of the RL-GL framework when analysing social-ecological dynamics. We have shown that it can be an effective tool to illustrate water resources challenges and can facilitate the implementation of policies or management practices to improve sustainability and resilience. In addition, we provide a novel application of the RL-GL framework to the management of water resources and demonstrate its utility in a context outside of the fields of ecology and conservation.

4. Conclusions

- Our analysis demonstrates how the novel application a social-ecological framework (RL-GL) to water resources issues can potentially improve the sustainability and resilience;
- This pilot study on a water resources system also contributes another example application of how the RL-GL framework can be used to visualise and identify detrimental, missing feedbacks in social-ecological systems;
- The South African example presents how the re-introduction of feedbacks can change behaviour to promote more sustainable water use and management practices; and
- Our article provides a conceptual, interdisciplinary approach to water resources management which should be applied more broadly and validated through empirical work.

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iii) SADC poster 2019

PhD Title: Groundwater Governance in South Africa: Governance and Preparedness for Hydraulic Fracturing

Candidate: Jack Hemingway – j.hemingway@Lancaster.ac.uk
Supervisors: Dr Alexandra Gormally – a.gormally@Lancaster.ac.uk (lead); Prof Gordon Walker (Lancaster University); Dr Nigel Watson (Lancaster University); Ms Brighid Ó Dochartaigh (British Geological Survey)

Lancaster University

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

1. Project overview

Groundwater is a common-pool resource that provides cheap, good quality water. This makes it an invaluable resource, but also leaves it vulnerable to pollution and over-abstraction. To meet these challenges, and to ensure groundwater is managed sustainably and equitably, it is necessary to have effective governance and management strategies (Villholth, 2018).

South Africa is seeing an increased interest in the exploitation of its extensive shale gas reserves, a development that could fundamentally alter the South African energy landscape and potentially be of enormous economic benefit, but which could also pose a threat to both groundwater quality, and the sustainable and equitable use of groundwater resources in an already water scarce region (Megdal et al., 2017; Stroebel et al., 2018). These developments present new challenges to effectively governing groundwater resources (Mechlem, 2016)

The objective of the research is to examine how the burgeoning shale gas industry in South Africa will impact groundwater, and how effective groundwater governance can mitigate these impacts.

2. Key components of groundwater governance

1: Actors: there are many actors involved in groundwater governance, including the private, public and third sectors and from a wide range of industries. Good governance requires strong **stakeholder participation**, and **effective cooperation and coordination** between the various actors.

2: Regulatory, legal and institutional frameworks: these define the rights and obligations for both the user and the administrative authority, and provide a starting point for policy development. It is necessary, therefore, to have **coordinated legislation** that is up-to-date and that **reflects the socio-ecological realities** on the ground.

3: Policies: for groundwater governance to be effective, water policy between different sectors needs to be coordinated, and created to be a **suitable spatial and temporal fit** for the challenges. This may involve **redrawing traditional governance boundaries**, or creating **more long-sighted policies**.

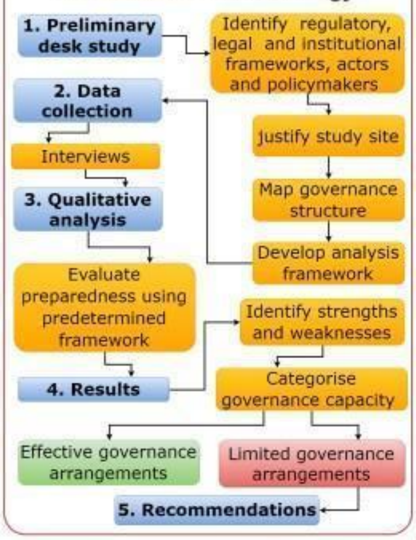
4: Knowledge, information and science: both physical information and socio-economic factors associated with groundwater uses must be considered when designing and implementing governance strategies. Good groundwater governance therefore must be **adequately funded** to enable sufficient data collection, and the **data must be shared between different sectors** and **clearly communicated** (GEF, 2016).

What is your opinion on hydraulic fracturing? How do you think it will impact the equitable and sustainable use of groundwater?

Please attach your thoughts, concerns, hopes and expectations to the panel below using the pen and paper provided, and if you wish, contact details so I can follow up on your suggestions

Call for Participants! If you would like to be involved in this research, please contact me. Thank you.

3. Research methodology



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iv) Participant information sheet

<u>Participant Information Sheet</u>

This sheet provides information regarding a PhD project in which you are being asked to participate. Please read this document carefully, and if you have any further questions, please feel free to contact either me or my supervisor, Dr Gormally. Thank you.

This research is funded by the British Geological Survey (BGS), and the ESRC North West Social Science Doctoral Training Partnership

Contact:

Lead Researcher:

Jack Hemingway

Lancaster Environment Centre

Lancaster University

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www.linkedin.com/in/jack-hemingway-5b1997101

07875508754

Lead Supervisor:

Dr Alexandra Gormally

a.gormally@lancaster.ac.uk

Other supervision:

Prof Gordon Walker, Professor, Lancaster University; Ms Brighid Ó Dochartaigh, Senior Hydrogeologist, British Geological Survey

In the unlikely event that participants need to contact a member of Lancaster University that is **not directly involved in the research**, to query or complain, please contact:

Professor Philip Barker

Director of Lancaster Environment Centre

Lancaster University

p.barker@lancaster.ac.uk

For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/dataprotection

PhD title: Unconventional Oil and Gas in South Africa: Science, Technology, and Policy

Project background: The research will be looking at the relationship between science and policy, specifically how hydrogeological and geological sciences are influencing the policies regarding the unconventional oil and gas (UOG) industry in South Africa.

South Africa is seeing an increased interest in the exploitation of both its extensive shale gas and coal seam gas reserves, developments that could fundamentally alter the South African energy landscape and potentially be of enormous economic benefit to the country. The promise of jobs, cheaper and cleaner fuel, and a massive GDP boost are particularly attractive to South Africa, given its ongoing energy and unemployment crises, but as in other countries, its adoption is proving controversial. The research will focus on how scientific knowledge influences policies on emergent technologies.

Why have you been contacted? You have been approached because of your specialist knowledge of groundwater science / policy / unconventional oil and gas. My research will be approaching people from across these disciplines to find out what they have to say about the uptake of new technologies in the field of unconventional oil and gas and given your expertise, it would be appreciated if you would participate in the research.

What will the research entail? I will be conducting semi-structured interviews that will take between 30 minutes and an hour discussing groundwater science / policy / unconventional oil and gas. You have the right to withdraw from the interview at any time without explanation, and the right to withdraw any data provided for the research, again, without explanation within 90 days of it being provided.

What are the advantages and disadvantages of taking part? There are no financial incentives for participation, however your input will contribute to a growing body of knowledge on groundwater governance and UOG technologies. You will be provided with a summary of the research when it is complete and will be given access to the research when it is publicly available. Given the nature of the research, there are no risks in participating.

Will my contribution remain anonymous? Yes. Only I, the lead researcher will have access to data linking an individual to the statements they provide for the research, all other readers will only be able to see a numbered code, thereby protecting the anonymity of the participants. If I co-author any work with my academic supervisors (see above), they may also need access to this data. The purpose of the research is to provide a critique of the uptake of new technologies in the UOG industry and its association with groundwater governance, so it will not be necessary to provide participants' names to achieve this end, but it will be necessary to provide organisational names. Given the specialised nature of the research, it cannot therefore be guaranteed that individuals with extensive insider knowledge would not be able to identify individuals based on their input, but I will nonetheless try to protect the anonymity of participants as best as Is reasonably practicable. I will personally be transcribing all of the interviews.

How is the data stored? All data will be stored in encrypted files or held on a password-protected laptop and in accordance with the General Data Protection Regulation (GDPR) and the (UK) Data Protection Act 2018. Hard copies of data will be stored in locked cabinets. For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/dataprotection

How will the information I provide be used? The information provided will be used for the purposes of academic research, meaning data collected will be transcribed where appropriate, coded and used as data for critical analysis. Some information given will appear as quotes in academic journals or the final PhD thesis, and other information will be used to create an overall picture of the way groundwater governance and UOG technologies are connected. The data will also be used (anonymously) at academic and industry conferences and in academic workshops.

How do I raise any concerns I may have? Any concerns regarding the project can either be raised with myself, my lead supervisor Dr Gormally, or any other part of my supervisory team (see above). The research is purely voluntary, and you also have the right to withdraw from the project within 90 days of the interview taking place, just let me or a member of the research team know you wish to remove yourself from the project and all your data will be removed and destroyed.

The project has been reviewed by the Research Ethics Committee at the Faculty of Science and Technology at the University of Lancaster

Thank you for your participation in this project.

Consent Form

Project title: Unconventional Oil and Gas in South Africa: Science, Technology, and Policy

Lead Researcher: Jack Hemingway

Email: j.hemingway@lancaster.ac.uk

www.linkedin.com/in/jack-hemingway-5b1997101

Please check each box

€ I confirm that I have read and understand the participant information sheet for the study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

€ I understand that my participation is voluntary and that I am free to withdraw from the study, without giving any reason. If I withdraw within 90 days of being interviewed my data will be removed from the research project and destroyed

€ I understand that any information given by me may be used in the research thesis, academic journals, publications or presentations by the researcher/s, but that the researcher will try to maintain participant anonymity by not including my personal information in research publications.

€ I understand that data will be kept according to University guidelines and destroyed within 3 years after the end of the study.

€ I agree to take part in the above study.

________________________	_______________	________________
Name of Participant	Date	Signature

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Signature of Researcher /person taking the consent ___________________ Date ___________

One copy of this form will be given to the participant and the original kept in the files of the researcher at Lancaster University

This research is funded by the British Geological Survey (BGS), and the ESRC North West Social Science Doctoral Training Partnership.

Thank you for your participation in this project.

v) Ethics Application Review (FSTREC)

Faculty of Science and Technology Research Ethics Committee (FSTREC)

Lancaster University

Application for Ethical Approval for Research

This form should be used for all projects by staff and research students, whether funded or not, which have not been reviewed by any external research ethics committee. If your project is or has been reviewed by another committee (*e.g.* from another University), please contact the FST research ethics officer for further guidance.

In addition to the completed form, you need to submit **research materials** such as:

i. Participant information sheets
ii. Consent forms
iii. Debriefing sheets
iv. Advertising materials (posters, e-mails)
v. Letters/emails of invitation to participate
vi. Questionnaires, surveys, demographic sheets that are non-standard
vii. Interview schedules, interview question guides, focus group scripts

Please note that **you DO NOT need to submit pre-existing questionnaires or standardized tests** that support your work, but which cannot be amended following ethical review. These should simply be referred to in your application form.

Please submit this form and any relevant materials by email as a **SINGLE attachment** to *fst-ethics@lancaster.ac.uk*

Section One

Applicant and Project Information

Name of Researcher: Jack Hemingway

Project Title: Groundwater Governance in South Africa: Governance and Preparedness for Hydraulic Fracturing

Level: Masters, PhD, Staff: PhD

Supervisor (if applicable): Dr Alexandra Gormally

Researcher's Email address: j.hemingway@lancaster.ac.uk

Telephone: 07875508754

Address: 127 Belvior Street, Hull, HU53LS

Names and appointments/position of all further members of the research team:

Prof Gordon Walker, Lecturer, Lancaster University; Dr Nigel Watson, Lecturer, Lancaster University; Ms Brighid Ó Dochartaigh, Senior Hydrogeologist, British Geological Survey

Is this research externally funded? If yes,

No

ACP ID number:

Funding source:

Grant code:

Does your research project involve any of the following?

☑ Human participants (including all types of interviews, questionnaires, focus groups, records relating to humans, use of internet or other secondary data, observation etc.)

☐ Animals - the term animals shall be taken to include any non-human vertebrates or cephalopods.

☐ Risk to members of the research team *e.g.* lone working, travel to areas where researchers may be at risk, risk of emotional distress

☐ Human cells or tissues other than those established in laboratory cultures

☐ Risk to the environment

☐ Conflict of interest

☐ Research or a funding source that could be considered controversial

☐ Social media and/or data from internet sources that could be considered private

☐ any other ethical considerations

Yes – complete the rest of this form

No – your project does not require ethical review or submission of this form

Section Two

Type of study

☒ Includes *direct* involvement by human subjects. ***Complete all sections apart from Section 3.***

☐ Involves *existing documents/data only*, or the evaluation of an existing project with no direct contact with human participants. ***Complete all sections apart from Section 4.***

If your research involves data from chat rooms and similar online spaces where privacy and anonymity are contentious, please complete all sections

Project Details

1. Anticipated project dates (month and year)

Start date: 01/12/2019 **End date:** 30/09/2021

2. Please briefly describe the background to the research (no more than 150 words, in lay-person's language):

The research will be looking at the relationship between science and policy, specifically how hydrogeological and geological sciences are influencing the policies regarding unconventional oil and gas (UOG) in South Africa.

South Africa is seeing an increased interest in the exploitation of both its extensive shale gas and coal seam gas reserves, developments that could fundamentally alter the South African energy landscape and potentially be of enormous economic benefit to the country. The promise of jobs, cheaper and cleaner fuel, and a massive GDP boost are particularly attractive to South Africa, given its ongoing energy and unemployment crises, but as in other countries, its adoption is proving controversial. The research will focus on how scientific knowledge influences policies on emergent technologies.

The research will be in 2 phases. Phase 1 will be research in the United Kingdom, for which ethics approval has already been granted, ref: FST19050, phase 2 will be research in South Africa. This ethics application form is specifically regarding Phase 2, the overseas fieldwork

3. Please state the aims and objectives of the project (no more than 150 words, in lay-person's language):

The aims of this project are to analyse the relationship between science, policy and technology uptake. It will aim do discover how groundwater science has influenced policy decision regarding the adoption of unconventional oil and gas (UOG) technologies in South Africa. The central objectives of the project will be: 1: to understand the potential impact that the UOG industry could have on groundwater, and what scientific practices are used to determine this impact, *e.g.* groundwater chemical baseline surveys, groundwater monitoring, and modelling techniques; 2: How this scientific knowledge is used to calculate risk and formulate policy, and; 3: how the previous 2 objectives combine to influence the adoption of emergent technologies, and the relationships and feed backs between these different processes.

4. Methodology and Analysis:

The UK section of the study will primarily be drawing on qualitative methods, namely document analysis and semi-structured interviews. I will be interviewing a range of stakeholders involved in the UOG industry, groundwater scientists, policy-makers and lawmakers. The questions will be determined by the speciality of the individual being interviewed but will be in keeping with the themes of the project, *i.e.* science, policy and technology uptake. The UK based interviews will be primarily fact based, dealing with scientific practices that will be used as the basis for the overseas section of the project. The overseas fieldwork will use the same methodological approach, however there will also be an ethnographic element to the research, in which diaries and field observations will also be used as primary data. Furthermore, I will be introducing electronic interviews, that is interviews via email, or other online communication platform, enabling me to keep an ongoing dialogue with participants regardless of geographical location.

Initially, interviewees will be staff from the British geological Survey (BGS), and the interviews will take place on BGS premises (The BGS are contributing significantly to the project, providing research funding and external supervision). However, it is hoped that these interviewees will provide further contacts for my research to follow *as such I am unable to give the exact location and demographic composition of all respondents, but it is certain they will all be adults, working within relevant industries and chosen purely according to their skillsets*.

Document analysis will involve researching all publicly available information regarding groundwater science and policy relating to the UOG industry in both the United Kingdom and South Africa.

Having completed the UK desk study and interviews, I will use the information to design the interviews and research plan for South Africa. Given the ongoing nature of the first phase of the research, exact questions for the overseas fieldwork have yet to be devised, but they are likely to be similar in content and theme to the examples provided in appendix iii.

Given the factual and non-sensitive nature of this section of the research, ethical and practical concerns will be minimal

Section Three

Secondary Data Analysis

Complete this section if your project involves *existing documents/data only*, or the evaluation of an existing project with no direct contact with human participants

1. Please describe briefly the data or records to be studied, or the evaluation to be undertaken.

2. How will any data or records be obtained?

3. Confidentiality and Anonymity: If your study involves re-analysis and potential publication of existing data but which was gathered as part of a previous project involving direct contact with human beings, how will you ensure that your re-analysis of this data maintains confidentiality and anonymity as guaranteed in the original study?

4. What plan is in place for the storage of data (electronic, digital, paper, etc)? Please ensure that your plans comply with the General Data Protection Regulation (GDPR) and the (UK) Data Protection Act 2018.

5. What are the plans for dissemination of findings from the research?

6a. Is the secondary data you will be using in the public domain? YES/NO

6b. If NO, please indicate the original purpose for which the data was collected, and comment on whether consent was gathered for additional later use of the data.

7.What other ethical considerations (if any), not previously noted on this application, do you think there are in the proposed study? How will these issues be addressed?

8a. Will you be gathering data from discussion forums, on-line 'chat-rooms' and similar online spaces where privacy and anonymity are contentious? YES/NO

If yes, your project requires full ethics review. Please complete all sections.

Section Four

Participant Information

Complete this section if your project includes *direct* involvement by human subjects.

1. Please describe briefly the **intended human participants** (including number, age, gender, and any other relevant characteristics):

The interviewees will typically be actors or stakeholders involved in either groundwater science or policy, unconventional oil and gas science or policy, or academics involved in either of the two aforementioned subjects. Besides specialists in the science / policy spheres, other parties with specialist interest in the area may also be consulted, such as NGOs, government officials or project managers. I will be looking to attract approximately 20 participants, from across the various spheres of my research. All participants will be chosen because of their specific expertise, and not based on age, gender, race or any other predetermined individual characteristic. All participants will be adults. Participants will probably be degree holders, although this will not be a requirement.

After the initial stage of my research, a further set of interviews will be carried out according to the preliminary findings, the participants for overseas fieldwork are similarly going to be professionals working in the fields of UOG or hydrogeology. The only new group of participants that are going to be introduced for the second phase of the research are water-users, such as farmers dependent on groundwater for their livelihoods. Again, all participants will be adults.

~~as these are yet to be determined, it is impossible to say what the demographics of the follow-on interviews will be. It is predicted the participants will also be professionals in the aforementioned fields. A further ethics form will therefore be submitted in due course, and before any follow-on work is carried out.~~

2. How will participants be **recruited** and from where?

Interviewees will be recruited according to their professional roles. These will be identified through desk-based research, for example by looking at authors of relevant published journals / books, speakers at relevant conferences, or authors / subjects of relevant press releases. I will also be contacting people through the BGS, via email introductions facilitated by my external supervisor within that particular organisation. I will be initially approaching all participants by their professional and publicly available email addresses. I will keep a detailed account of all email addresses on a password protected computer. Given the public nature of the email addresses, it is not thought that this method of contacting participants will raise any ethical concerns. Another method of storing addresses available to me would be to store them in a locked cabinet in my Lancaster Environment Centre office, according to the preferences of the FST ethics committee. All data will be deleted / destroyed within 36 months of the project's completion. Once the initial round of interviews has been conducted, it is predicted further participants will be contacted according to the "snowball" method, that is, participants will refer me to their colleagues or other relevant professional acquaintances.

Recruiting overseas participants will involve a similar approach, initially using contacts made through my supervision team, and my desk-studies, and then applying the "snowball" technique to recruit further participants.

3. Briefly describe your **data collection methods**, drawing particular attention to any potential ethical issues.

The research will primarily be comprised of semi-structured interviews. This method allows the interviewer to set the framework for discussion, but also affords the interviewee the freedom to elaborate on points they deem more appropriate, or to introduce other topics into the interview that they believe relevant. The interviews will be based in the subject of groundwater science / policy, unconventional oil and gas science / policy and science and technology studies. Other data collection methods will be desk-based studies, press releases and conference talks / conversations held at academic / industry conferences. The data will be used to critically analyse the uptake of new technologies. It is believed this method of data collection will not raise any ethical issues.

The interviews will be carried out as follows: 1; email introduction; 2: consent; 3: introduction of the project; 4; reason for my conducting the project (i.e. PhD thesis); 5: interview; 6: close out email. The interview will consist of introductory questions confirming the participants current employment and expertise and then will follow the semi-structure prepared for the interviews. The interviews will be quite explorative, allowing the participants to elaborate or introduce new topics to the discussion, as this is how I will be generating data. Interviews will follow a different structure according to the specialisation of the interviewee. The length of the interviews is also likely to vary but will typically be under an hour. Interviews will take place either over the phone or in person. When conducted in person, it will either be in the interviewees place of work or at Lancaster University.

Standard practices regarding confidentiality will be upheld. The interviews will be designed to allow confidentiality should the participant wish, and it is not foreseen any sensitive / compromising data will be revealed. Participants will have it explained to them that they are under no obligation to answer any questions they do not want to, and that they can terminate the interview at any given time without explanation. The participants will also be given the opportunity to withdraw their interview from the project within a 90-day period after the interview takes place. Given that the interviewees will be experts in their relative fields, it is expected they will be well informed about the subjects discussed, it is therefore considered unlikely that any unforeseen areas of discussion will arise in the interviews that are likely to give participants cause for concern. What information is considered sensitive will vary according to individual, and therefore cannot be determined by myself, so if a participant either intentionally or unintentionally provides information they consider sensitive and wish to withdraw on reflection, they will be at liberty to do so, I will remind all participants of this fact at the end of the interview, and in the follow-up email that will be sent to participants. I will also provide participants an opportunity to ask me any questions or seek clarification on any aspect of the research at the close of interview, and in follow up emails.

I will also be collecting data using ongoing email and messaging services. The consent process for this data collection method will be the same as for the interviews, so I will make it clear at which point our conversations will become part of my research project, that is, once written, formal consent has been obtained.

Field diaries will be kept of my overseas research, including observations, notes, dates and times of events and any other information that might be relevant for my research. If this involves any discussions with individuals that I wish to include in my research, the same procedures of consent for interviews will be followed.

4. Consent

4a. Will you take all necessary steps to **obtain the voluntary and informed consent** of the prospective participant(s) or, in the case of individual(s) not capable of giving informed consent, the permission of a legally authorised representative in accordance with applicable law?

NO

If yes, please go to question 4b. If no, please go to question 4c.

4b. Please explain the procedure you will use for **obtaining consent**. If applicable, please explain the procedures you intend to use to gain permission on behalf of participants who are unable to give informed consent.

4c. If it will be necessary for participants to take part in the study **without their knowledge and consent at the time**, please explain why (for example covert observations may be necessary in some settings;

some experiments require use of deception or partial deception – not telling participants everything about the experiment).

I will not be conducting any covert research. I do however intend to recruit participants at academic or industry conferenced, but in these instances, I will ask to contact individuals outside the conference and then treat them as regular participants in the research and follow all aforementioned consent procedures.

Prior to commencement of interviews, participants will be told the reason for my research, and asked for consent to use the statements they provide during the course of the interview for my research. They will be informed that they can withdraw their statements within 90-days of the completion of the interview(s). I will ask for consent for the interviews to be recorded. Formal, written consent forms will be given to participants before any interviews take place, and their completion will be a requirement for participation in the research, so they can be confident their data will be properly managed (see attached consent form appendix iv), and to provide myself, the university and the participant with a written document consenting to the research to ensure there are no misconceptions about the study prior to participating.

I intend to use ongoing correspondence as primary data using email or other messaging services according to the priority of the individual being interviewed. In these instances, the same consent and data protection procedures will be followed as for the standard interviews.

5. Could participation cause **discomfort** (physical and psychological *e.g.* distressing, sensitive or embarrassing topics), **inconvenience or danger beyond the risks encountered in normal life**? Please indicate plans to address these potential risks. State the timescales within which participants may withdraw from the study, noting your reasons.

Discomfort, inconvenience or danger to participants is not anticipated. Participants will be professional adults and will be able to judge for themselves the possibility of any inconvenience, but as previously stated, participants will be informed of their option to withdraw their statements from the research should they reconsider. Interviewees are also at liberty to refuse to answer questions or terminate interviews at any point without explanation.

6. How will you protect participants' **confidentiality and/or anonymity** in data collection (*e.g.* interviews), data storage, data analysis, presentation of findings and publications?

To protect confidentiality and / or anonymity, participants will be assigned a number by which to identify them, rather than using their name or their organisations name. I will however keep a separate document linking participants with their respective organisations as this will be an essential part of the data analysis, but which will not be included in the research write-up. This will be kept on a password protected computer. Any handwritten documents I make throughout the course of the research will be kept in my locked cabinet in my office in Lancaster Environment Centre. All transcripts of interviews will adhere to the numbering system, therefore, to ascertain an individual's identity, it would be necessary to have both the document and the numerical key, which will be kept separate. All data will be destroyed 36 months after completion of the research. All data storage will adhere to the General Data Protection Regulation (GDPR) and the (UK) Data Protection Act 2018. All transcription will be done by myself, so participants and the FSTREC ethics committee can be sure participant confidentiality will be maintained. All transcription work will be carried out by myself.

While anonymity will be provided to individuals, it will not be possible to conceal the identity of organisational actors, *e.g.* the BGS, as certain institutions perform specific roles that would be determinable by persons with knowledge in the spheres of this research. Being able to identify organisations will also be significant as it will allow critical analysis that will be essential to the completion of the research.

Data collected by email or other messaging platform will be kept on a password protected device, and will be subject to the same data protection measures as other data. The exception to this rule would be the destruction of data where data is held by the host platform, as is the case with Facebook Messenger, in which case all practicable efforts to delete the data will be made, that is I will delete messages, but data held by the host platform will remain. This will be explained to the participants clearly before any data collection of this type takes place. Data can be withdrawn at any point up to 90 days of the completion of the data collection, that is 90 days after the most recent correspondence.

7. Do you anticipate any ethical constraints relating to **power imbalances or dependent relationships**, either with participants or with or within the research team? If yes, please explain how you intend to address these?

I do not foresee there being any significant power imbalances during the course of my research. As previously mentioned, participants are expected to be professionals, often working in large organisations in which clear guidelines will be set out for employees to follow.

8. What potential **risks may exist for the researcher** and/or research team? Please indicate plans to address such risks (for example, noting the support available to you/the researcher; counselling considerations arising from the sensitive or distressing nature of the research/topic; details of the lone worker plan you or any researchers will follow, in particular when working abroad.

For the UK section of this research, I do not anticipate any significant risks that would not otherwise be present in day-to-day life. All interviews will take place in either mine or the participant's place of work and given the nature of the research this is most likely going to be offices or break rooms. Should I visit any drilling sites, all necessary procedures will be followed, including site inductions, and following site safety procedures.

For the overseas fieldwork, it is predicted that the research will take place in similar environments to the UK research, that is participant's places of work. The only difference that is foreseen is that interviews held with water-users may involve travelling to farms, in which case interview are likely to take place on farm premises which would potentially include the farmers' homes. Again, risk from this type of data collection is thought to be minimal.

The main risk identified with this method of data collection is the remote location of the potential candidate's places of work. To mitigate the threat of travelling to remote areas alone, a check-in system will be used, whereby I let designated people know where I am travelling to, when I set off, when I arrive, when I depart, and when I return to my final destination. I will nominate 2 people, 1 in the UK and 1 in South Africa. A satellite phone will be used to ensure network coverage. Travel to and from remote places will be by car. Suitable breakdown cover and insurances will be purchased where appropriate.

All local travel guidelines will be followed to mitigate the threat of crime and the threat of wildlife.

9. Whilst there may not be any significant direct **benefits to participants** as a result of this research, please state here any that may result from participation in the study.

The research is unlikely to provide any direct or indirect benefit to participants. Given that the research will be focussing on the policy and science that inform the uptake of new technologies, it is difficult to imagine how any of the individual participants could indirectly benefit from this research. The research may identify certain risks, and methodologies of research that may not have been otherwise obvious to participants, and could be of academic interest to participants, but direct or indirect benefits are not anticipated.

10. Please explain the **rationale for any incentives/payments** (including out-of-pocket expenses) made to participants:

No payments of any type will be made

11. What are your plans for the **storage of data** (electronic, digital, paper, etc.)? Please ensure that your plans comply with the General Data Protection Regulation (GDPR) and the (UK) Data Protection Act 2018.

Guidelines for storage of data have been described in **section 6.**

12. Please answer the following question *only* if you have not completed a Data Management Plan for an external funder.

12.a How will you make your data available under open access requirements?

12b. Are there any restrictions on sharing your data for open access purposes?

13. Will **audio or video recording** take place? ☐ no ☑ audio ☐ video

13a. Please confirm that portable devices (laptop, USB drive etc) will be **encrypted** where they are used for identifiable data. If it is not possible to encrypt your portable devices, please comment on the steps you will take to protect the data.

Audio recordings of interviews will be made and will be stored on an encrypted laptop. Once the files have been transferred from the recording device (where applicable), the originals will be immediately destroyed. Transcriptions will adhere to a numbering system to ensure anonymity, and the key to this system will be stored on a separate file. All hard copies of transcripts will be kept in a locked cabinet in my office in LEC and will be transcribed in a way that ensures anonymity, that is without including names and organisations of participants. All personal information linked to the participants, for example CVs, will be kept separate on an encrypted laptop, in a standalone file.

13b. What arrangements have been made for **audio/video data storage**? At what point in the research will tapes/digital recordings/files be destroyed?

All audio data from the project will be destroyed within 3 years of the completion of the project.

13c. If your study includes video recordings, what are the implications for participants' anonymity? Can anonymity be guaranteed and if so, how? If participants are identifiable on the recordings, how will you explain to them that you will do with the recordings? How will you seek consent from them?

Video data will not be collected as part of this research.

14. What are the plans for dissemination of findings from the research? If you are a student, mention here your thesis. Please also include any impact activities and potential ethical issues these may raise.

I intend to publish my findings in academic journals. The research is part of a PhD, so it will therefore be finally compiled into an academic thesis, submitted to the University of Lancaster. All participants in the research will be provided with an executive summary of the completed research and will be offered access the thesis should they desire access. I am also planning on sharing my research at academic conferences and in academic groups and workshops. I do not anticipate that these actions will present any ethical issues

15. What particular ethical considerations, not previously noted on this application, do you think there are in the proposed study? Are there any matters about which you wish to seek guidance from the FSTREC?

There are no other ethical considerations expected from this research.

Section Five

Additional information required by the university insurers

If the research involves either the nuclear industry or an aircraft or the aircraft industry (other than for transport), please provide details below:

Section Six

Declaration and Signatures

I understand that as Principal Investigator/researcher/PhD candidate I have overall responsibility for the ethical management of the project and confirm the following:

- I have read the Code of Practice, Research Ethics at Lancaster: a code of practice and I am willing to abide by it in relation to the current proposal.
- I will manage the project in an ethically appropriate manner according to: (a) the subject matter involved and (b) the Code of Practice and Procedures of the University.
- On behalf of the University, I accept responsibility for the project in relation to promoting good research practice and the prevention of misconduct (including plagiarism and fabrication or misrepresentation of results).
- On behalf of the University, I accept responsibility for the project in relation to the observance of the rules for the exploitation of intellectual property.
- If applicable, I will give all staff and students involved in the project guidance on the good practice and ethical standards expected in the project in accordance with the University Code of Practice. (Online Research Integrity training is available for staff and students here.)
- If applicable, I will take steps to ensure that no students or staff involved in the project will be exposed to inappropriate situations.

- I confirm that I have completed all risk assessments and other Health and Safety requirements as advised by my departmental Safety Officer.

☑ Confirmed

Please note: If you are not able to confirm the statement above, please contact the FST Research Ethics Committee and provide an explanation.

<u>Student applicants</u>:

Please tick to confirm that you have discussed this application with your supervisor, and that they agree to the application being submitted for ethical review ☒

<u>Students must submit this application from your Lancaster University email address, and copy your supervisor in to the email in which you submit this application</u>

<u>All Staff and Research Students must complete this declaration:</u>

I confirm that I have sent a copy of this application to my Head of Department (or their delegated representative) . **Tick here to confirm** ☒
Name of Head of Department *(or their delegated representative)* Prof. Philip Barker

Applicant electronic signature:  Date 13/01/2020

Appendix i: Example letter of invitation

Dear Sir / Madam,

My name is Jack Hemingway and I am PhD researcher at Lancaster University. I am currently carrying out research on how groundwater science and groundwater policy can influence the uptake of new technologies relating to the unconventional oil and gas industry. The focus of my research is on the

UOG industry in South Africa, and I am hoping to recruit participants with expertise in this area of research for my project

Given your expertise in the field of… I am hoping you would be willing to participate in my research, and spend some time either in person or over the phone discussing… I intend to keep all interviews under an hour. Your perspective on… will be highly beneficial to this project.

There are no material benefits to participating in this research, nor are there any risks involved, but your participation would contribute to a growing body of work involving groundwater governance and the UOG industry and would be greatly appreciated. All information provided will be kept confidential and anonymised at industry level in accordance with my commitments to the ethics department at Lancaster University. Please find attached a participant information sheet outlining further details of the study, and also all information regarding the handling of data.

I look forward to hearing from you.

Regards.

Jack Hemingway

1. Appendix ii: Participant information Sheet, Draft copy

Participant Information Sheet

This sheet provides information regarding a PhD project in which you are being asked to participate. Please read this document carefully, and if you have any further questions, please feel free to contact either me or my supervisor Dr. Gormally. Thank you.

Contact:

Lead Researcher:

Jack Hemingway

Lancaster Environment Centre

Lancaster University

j.hemingway@lancaster.ac.uk

07875508754

Lead Supervisor:

Dr Alexandra Gormally

a.gormally@lancaster.ac.uk

Other supervision:

Prof Gordon Walker, Lecturer, Lancaster University; Dr Nigel Watson, Lecturer, Lancaster University; Ms Brighid Ó Dochartaigh, Senior Hydrogeologist, British Geological Survey

In the unlikely event that participants need to contact a member of Lancaster University that is **not directly involved in the research**, to query or complain, please contact:

Professor Philip Barker

Director of Lancaster Environment Centre

Lancaster University

p.barker@lancaster.ac.uk

For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/dataprotection

PhD title: Groundwater Governance in South Africa: Governance and Preparedness for Hydraulic Fracturing

Project background: The research will be looking at the relationship between science and policy, specifically how hydrogeological and geological sciences are influencing the policies regarding the unconventional oil and gas (UOG) industry in South Africa.

South Africa is seeing an increased interest in the exploitation of both its extensive shale gas and coal seam gas reserves, developments that could fundamentally alter the South African energy landscape and potentially be of enormous economic benefit to the country. The promise of jobs, cheaper and cleaner fuel, and a massive GDP boost are particularly attractive to South Africa, given its ongoing energy and unemployment crises, but as in other countries, its adoption is proving controversial. The research will focus on how scientific knowledge influences policies on emergent technologies.

Why have you been contacted? You have been approached because of your specialist knowledge of groundwater science / policy / unconventional oil and gas. My research will be approaching people from across these disciplines to find out what they have to say about the uptake of new technologies in the field of unconventional oil and gas and given your expertise it would be appreciated if you would participate in the research.

What will the research entail? I will be conducting semi-structured interviews that will take between 30 minutes and an hour discussing groundwater science / policy / unconventional oil and gas. You have the right to withdraw from the interview at any time without explanation, and the right to withdraw any data provided for the research, again, without explanation within 90 days of it being provided.

What are the advantages and disadvantages of taking part? There are no financial incentives for participation, however your input will contribute to a growing body of knowledge on groundwater governance and UOG technologies. You will be provided with a summary of the research when it is complete and will be given access to the research when it is publicly available. Given the nature of the research, there are no risks in participating.

Will my contribution remain anonymous? Yes. Only I, the lead researcher will have access to data linking an individual to the statements they provide for the research, all other readers will only be able to see a numbered code, thereby protecting the anonymity of the participants. If I co-author any work with my academic supervisors (see above), they may also need access to this data. The purpose of the research is to provide a critique of the uptake of new technologies in the UOG industry and its association with groundwater governance, so it will not be necessary to provide participants' names to achieve this end, but it will be necessary to provide organisational names. Given the specialised nature of the research, it cannot therefore be guaranteed that individuals with extensive insider knowledge would not be able to identify individuals based on their input, but I will nonetheless try to protect the anonymity of participants as best as Is reasonably practicable. I will personally be transcribing all of the interviews.

How is the data stored? All data will be stored in encrypted files or held on a password-protected laptop and in accordance with the General Data Protection Regulation (GDPR) and the (UK) Data Protection Act 2018. Hard copies of data will be stored in locked cabinets. For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/dataprotection

How will the information I provide be used? The information provided will be used for the purposes of academic research, meaning data collected will be transcribed where appropriate, coded and used as data for critical analysis. Some information given will appear as quotes in academic journals or the final PhD thesis, and other information will be used to create an overall picture of the way groundwater governance and UOG technologies are connected. The data will also be used (anonymously) at academic and industry conferences and in academic workshops.

How do I raise any concerns I may have? Any concerns regarding the project can either be raised with myself, my lead supervisor Dr Gormally, or any other part of my supervisory team (see above). The research is purely voluntary, and you also have the right to withdraw from the project within 90 days of the interview taking place, just let me or a member of the research team know you wish to remove yourself from the project and all your data will be removed and destroyed

The project has been reviewed by the Research Ethics Committee at the Faculty of Science and Technology at the University of Lancaster

Thank you for your participation in this project.

Appendix iii: Sample interview questions

- What science is being used to determine risk to groundwater on site? What monitoring programmes are in place? What is being measured? How frequently? And by whom?
- Is water use increasing or decreasing during the drilling and fracturing process? Are the more productive wells using more water?
- What groundwater science is being routinely carried out as part of the exploration process, including: baseline status and measurements; monitoring; safeguarding; remediation; decommissioning (*e.g.* NAO report)?

- What technology is employed to address the threat to groundwater from hydraulic fracturing?
- How can "Pristine ecology" and background data provides an opportunity to demonstrate effective and clean exploitation of shale and coal seam gases.
- What groundwater science is being applied to the decision-making processes surrounding the development of unconventional gas resources?
- How much does the perception of the threat to groundwater influence stakeholder opinion on fracking?
- How do policy-makers address discrepancies between expert advice *e.g.* BGS / Cuadrilla?

Sample interview conversation topics

- Address the concept of risk to groundwater from unconventional gas exploration and extraction, including: the different perceptions of risk from different stakeholders; risk thresholds *i.e.* seismic "traffic light" system.
- Trade-offs encountered when changes are introduced to the water-energy-food nexus, particularly energy – water trade-offs, and water use conflicts in water scarce environments, and risk-reward trade-offs.
- Positive and negative feedbacks between science, stakeholder opinion and policy
- The importance of social licences, how these are won and / or lost. Stakeholder perception and trust of experts, politicians, private companies.
- Possible chronological comparisons between UK and RSA policy

Appendix iv: Consent form

Consent Form

Project title: Groundwater Governance in South Africa: Governance and Preparedness for Hydraulic Fracturing

Lead Researcher: Jack Hemingway

Email: j.hemingway@lancaster.ac.uk

Please check each box

€ I confirm that I have read and understand the participant information sheet for the study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

€ I understand that my participation is voluntary and that I am free to withdraw from the study, without giving any reason. If I withdraw within 90 days of being interviewed my data will be removed from the research project and destroyed

€ I understand that any information given by me may be used in the research thesis, academic journals, publications or presentations by the researcher/s, but that the researcher will try to maintain participant anonymity by not including my personal information in research publications.

€ I understand that data will be kept according to University guidelines and destroyed within 3 years after the end of the study.

€ I agree to take part in the above study.

_________________________ ________________ _________________

Name of Participant Date Signature

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Signature of Researcher /person taking the consent___________________________ Date ___________

One copy of this form will be given to the participant and the original kept in the files of the researcher at Lancaster University

vi) Imageries pertaining to the importance of water in the national psyche of South Africa

Above images were all taken by the author in the city of Cape Town, RSA.