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A coal transition vulnerability index for South Africa

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ABSTRACT

Growing concern over climate change impacts across the world has prompted significant commitments to cleaner energy systems and a 'just transition' framework for ensuring equitable outcomes. The transition will have significant implications for communities reliant on coal mines and plants for jobs, training, service delivery and local economic viability. South Africa is particularly affected due to its heavy reliance on coal for electricity and jobs, especially in the context of the country's high unemployment rates. Vulnerability is multidimensional and comprises of exposure (the degree to which a region or community is susceptible to closure of mines and plants), sensitivity (the extent to which coal phase-down may cause social and economic disruption), and adaptive capacity of people and institutions. This study uses 19 indicators to quantify a Coal Transition Vulnerability Index (CTVI) for 29 coal municipalities in South Africa. Results show significant variation across components and highlight hotspots in Mpumalanga that are most vulnerable to the energy transition. The effect of adaptive capacity shows the importance of local economic development, service delivery, and governance in shaping transition outcomes. The distinct vulnerability profiles can be used to inform just transition policies and programmes in South Africa that support placed-based strategies.

1. Introduction

1.1. Global just transition

Growing concern over climate change impacts across the world has led to the widely shared goal of a "just transition" to cleaner energy sources and reduced dependence on coal (World Bank Group, 2018). At least 36 governments and 54 companies have committed to phasing out thermal coal from the power sector by 2030 and have thereby established dedicated "just transition" task forces, coal transition commissions, and multi-stakeholder consultation platforms, among others, to navigate this complex shift (Edwards et al., 2022; Government of Canada, 2018; Petrini, 2023; Popp and De Pous, 2021; Ruppert Bulmer et al., 2021). This transition has significant implications for coal-producing countries that rely on coal-fired power and/or coal exports (Glynn et al., 2021). Coal workers and their families and communities face loss of employment, income, revenue, and basic services, and may be forced to move to find work and/or to accept lower wages (Steadman et al., 2024). Although renewable energy jobs have been growing rapidly worldwide, these opportunities typically require different skills and are often located in regions that do not overlap with those most affected by coal phase-down (IRENA, 2024). A key goal of the "just transition" is to ensure that no-one is left behind when making necessary changes to energy and economic systems; that involves sharing the costs and benefits of the changes fairly, supporting workers with new jobs or retraining, ensuring adequate safety nets, and supporting communities and small businesses through broader economic changes (IRENA and ILO, 2021).

The concept of a "just transition" originated with trade unions in the 1970s that were focused on protecting fossil fuel workers from economic displacement. However, the concept has since evolved to encompass broader social, economic, and environmental dimensions of sustainability transformations and now encompasses a range of definitions, interpretations and understandings (Wang and Lo, 2021). Contemporary just transition frameworks increasingly recognize the need to address systemic inequalities, promote inclusive governance, and ensure equitable distribution of both transition costs and benefits across diverse stakeholders and communities (Newell and Mulvaney, 2013; Stevis and

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Felli, 2020). The energy transition will not occur in a vacuum, it will take place within existing energy and socio-economic systems marked by pervasive inequities and injustices that cannot be ignored or perpetuated (Marais et al., 2022) and must address the existing injustices within the global energy system while focusing on avoiding new forms of injustice (Bhullar, 2023; Sovacool, 2013). The framework of energy justice emphasizes the importance of balancing the three domains of economics, politics and environment by using fairness and equity as guiding concepts (Sovacool and Dworkin, 2014). A justice-oriented approach demands intergenerational considerations and maintain the principles of recognition, distributional, reparative, and procedural justice at its core (Bazilian et al., 2021). When viewed through a justice lens, gaps in current energy policies become evident and point to the need for greater attention to issues of diversity and inclusion (CSIS and CIF, 2021). Beyond the distributional justice concerns of who benefits and who bears costs, procedural justice demands meaningful participation in decision-making, while recognition justice requires acknowledging historically marginalized groups whose experiences and knowledge are often excluded from transition planning (Jenkins et al., 2018; McCauley, 2023).

The social impacts of mine closure are fairly well documented, especially in the UK and the USA (Bulmer, 1971; House, 1967; Jones, 1993; Miller, 1990; Milne, 1993a; 1993b; Sewel, 1975, 1968; Turner, 1993a; 1993b, 1985). However more attention needs to be placed on the lived experiences of individuals and communities while framing the energy transition debates (Brown and Spiegel, 2019). Rapid mine closure can exacerbate socio-economic vulnerabilities, especially when governments and communities are not well-prepared for closure. Effective transition requires early-stage planning, continuous and meaningful stakeholder engagement, and methodical sequencing of income support and labour market policies and interventions (World Bank Group, 2018). Experience from Canada illustrates the need to engage directly with affected communities to identify local priorities as well as the value of establishing a targeted, long-term research fund for assessing the impact of the coal phase-out (Government of Canada, 2018). International literature further indicates that entrenched institutional systems, narrow worker skills, poor environmental conditions, geographical isolation, and lack of investor interest in alternate sectors, can trigger significant decline in areas dominated by a single industry like coal (Nel et al., 2023). Creating just and equitable transition policies requires systematic data collection and robust analysis on the impacts of the energy system and mapping out of the changes as fossil fuels are replaced by renewables (Cabré and Vega-Araújo, 2022).

Vulnerability of communities to shocks can differ widely between places and regions and can change over time, and is shaped by multiple factors related to governance, infrastructure, basic services and historical factors (IPCC, 2022). Regional disparities exacerbate this issue, particularly in coal-dependent areas that tend to be geographically isolated, mono-economy based, and marked by workforce immobility, all of which intensifies the negative impacts of energy transition (Nel et al., 2023). Thus, scholars have called for more extensive research into the various socio-economic dimensions of just transition to better understand and reconcile the multifaceted challenges it presents (Bazilian et al., 2021). Agrawal et al. (Agrawal et al., 2024) have recently conceptualized vulnerability in the context of just transition as a combination of three components: (i) the degree to which a region is susceptible to the transition away from coal and the resultant closure of mine and plant infrastructure (exposure), (ii) the extent to which coal phase-down may cause social and economic disruption (sensitivity), and (iii) the ability of people, systems, and institutions to adjust to potential negative change, to take advantage of opportunities, and/or to respond to consequences (adaptive capacity). Using this framework, the authors have quantified vulnerability in India's coal regions to understand the distribution of coal phase-down impacts and identify trade-offs and synergies between developmental policies and climate change mitigation (Agrawal et al., 2024).

1.2. The South African context

South Africa is the world's seventh biggest coal producer at 2.5 % of global coal production after China (51.7 %), India (11.7 %), Indonesia (9 %), Australia (5.0 %), USA (5.0 %), and Russia (4.6 %) (Energy Institute, 2023). About 28 % of coal is exported, largely to India and Europe (Minerals Council South Africa, 2025). The major domestic users of coal are national state-owned utility Eskom (53 % of total production), Sasol's coal-to-liquid (CTL) fuel plant (33 %), and aluminum and ferro-alloys producers (12 %) (Eskom, 2021). The country's dependence on coal for electricity is the highest in the world at 83 % compared to 72 % in India, 68 % in Indonesia, 62 % in China and a global average of 33 % (IEA, 2025). Hydropower (6.4 %), other renewables (7.3 %), nuclear (4.6 %) and diesel (1.6 %) produce the balance (Pierce and Le Roux, 2023). South Africa's total energy consumption (oil, gas and coal) resulted in 438.9 $MtCO_2$ emissions in 2021 (BP, 2022).

The coal mining industry has been an important part of the South African economy since the late 1800s when it supported the growth of the gold and diamond mining industries and industrialisation (Cole and Broadhurst, 2020). South Africa produces mostly thermal coal used for power generation in Mpumalanga province, with metallurgical coal largely limited to the Waterberg and Soutpansberg coalfields in Limpopo province and the Natal coalfield in KwaZulu-Nata province. International climate commitments to reduce GHG emissions have led to multinational companies divesting thermal coal assets to local companies. In 2024, the coal mining industry directly employed 98,425 people who collectively earned R36.4 billion (USD 1.9 bn), recorded total sales of R195.6 billion (USD 10.4 bn) and contributed R3.8 billion (USD 0.2 bn) in royalties (Minerals Council South Africa, 2025); in 2021 the coal industry spent R61 billion (USD 3.4 bn) procuring goods and services (Minerals Council South Africa, 2022). The median wage of coal mine workers is double that of other formal sector workers in South Africa (Pai et al., 2021) and the vast majority receive pensions, medical aid, annual leave and unemployment insurance (Bhorat et al., 2024; Cruywagen, 2020). Operating coal mines are located in five provinces, 11 district municipalities, two metropolitan municipalities and 27 local municipalities, home to over 10 million people. More specifically, there are at least 70 mining host communities (settlements located close to a coal mine) which are home to over 2.5 million people (Cole et al., 2023). These communities are very diverse and include cities, large towns, small mining towns, mine villages, townships, informal settlements and rural villages.

State utility Eskom operates 14 coal-fired power plants with a 43 GW capacity in coal mining regions in Mpumalanga, Free State and Limpopo provinces that employ over 10,000 people (Cole et al., 2023). Most of Eskom's plants are >30 years old and four are >50 years old and are due to retire before the end of 2030 (Creamer, 2024). The national Integrated Resource Plan (IRP) 2019 sets out the decommissioning schedule for all the plants, with Camden, Hendrina and Grootvlei set to close in 2025, and Arnot and Kriel in 2029 (DMRE, 2019) while the draft IRP 2023 out for public comment sees Grootvlei closing two years later in 2027 and Kriel closing one year later in 2030 (DMRE, 2024). Komati plant was decommissioned in October 2022 and is set to be a 'just transition' pilot site for repurposing to renewable energy (solar PV, wind and battery storage) with USD 497 million in concessional loans and grants secured from the World Bank (Eskom, 2022). A major limitation to the shift to renewable energy is how quickly the transmission grid can be expanded to the areas with maximum solar and wind power potential in the Northern Cape, Eastern Cape and Western Cape provinces. If renewable energy cannot come online, the retirement dates of the coal plants will likely be delayed to avoid load shedding.

South Africa's just transition policy landscape has evolved rapidly since 2018, moving from conceptual discussions to concrete financing mechanisms and implementation frameworks. South Africa's efforts to reduce its reliance on coal and thus GHG emissions are guided by the Presidential Climate Commission (PCC), established in 2020 in response

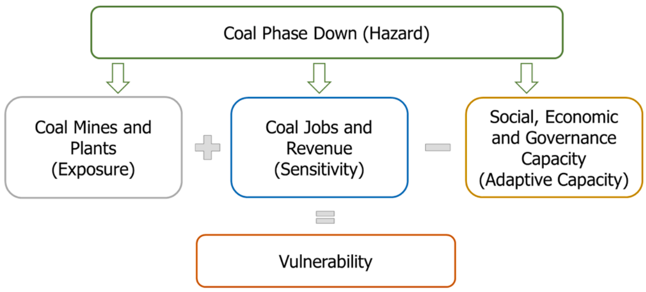

Fig. 1. Conceptual framework for assessing vulnerability to coal phase down (Adapted from Agrawal et al., 2024).

to the need for coordinated and effective climate action. The PCC is required to ensure that South Africa's climate policies are equitable, inclusive, and aligned with the country's socio-economic goals. South Africa's Just Transition Framework, published in 2022, serves as the primary document for coordinating the country's transition to a low-carbon economy and highlights the vulnerability of the coal value chain. The framework is anchored in three principles of distributive justice, restorative justice and procedural justice and defines the just transition to encompass principles of mitigation, resilience, decent work, social inclusion and poverty alleviation (Presidential Climate Commission, 2022). South Africa's Just Energy Transition Investment Plan (JET IP) for the period 2023–2027 lays out priority investments requiring over USD 100 billion in the electricity (48 %), new energy vehicles (9 %) and green hydrogen (22 %) sectors, alongside investments in municipal capacity (22 %) and skills development (0.2 %), highlighting the breadth of interventions required (The Presidency Republic of South Africa, 2022). Funding of close to USD 12.5 bn has been pledged by international partners (including the US, UK, Germany, France and the EU) through the world's first Just Energy Transition Partnership (JETP) (Kramer, 2022). A national Just Energy Transition Implementation Plan subsequently published in 2023, details institutional arrangements, implementation strategies, and funding requirements (The Presidency Republic of South Africa, 2023).

While substantial progress has been made at the national level, the pace of implementation of policies and programs at the local level where the coal mines and plants will close and specific local communities will be affected, has been slow (Strambo et al., 2019; Winkler et al., 2020). Significant knowledge gaps also remain regarding the spatial distribution of vulnerability leading scholars and practitioners to highlight the need for data collection and mapping for just transition policy-making (see, for example, (Montmasson-Clair et al., 2022). This paper seeks to address this gap by developing a systematic assessment of vulnerability to coal phase-down at the local scale, by adapting Agrawal et al.'s (2024) framework for South Africa and to develop a Coal Transition Vulnerability Index (CTVI) for South African coal municipalities. Measuring and mapping exposure, sensitivity, adaptive capacity and overall vulnerability at the local level will enable more targeted and differentiated policy responses that reflect the heterogeneous challenges facing diverse coal-dependent regions.

2. Method

Composite indexes are widely used as they help simplify complex indicators and are easier to interpret than multiple individual datasets. However, to be effective, they should contribute to a greater understanding, generate new insights, and be fit for purpose. The framework for assessing vulnerability to coal transitions developed by Agrawal et al. (2024) achieves this by aggregating a diverse set of indicators specifically chosen to reflect the multifaceted nature of transition impacts. This study adapts Agrawal et al.'s (2024) conceptual framework for the South African context and expands it to include 'governance' as part of the 'adaptive capacity' component (see Fig. 1). This addition is particularly important in the South African context, where municipal governance quality varies dramatically and directly impacts service delivery, economic development capacity, and ultimately transition outcomes.

Table 1
Indicators and data sources for the coal transition vulnerability index in South Africa.

Component	Indicator	Data source
Exposure	Number of coal mines	SA Operating Mines dataset (Cole, 2024)
	Total coal mine production (Mtpa)	SA Operating Mines dataset (Cole, 2024)
	Average life of mine (years)	SA Operating Mines dataset (Cole, 2024)
	Coal plant capacity (MW)	Global Coal Plant Tracker (GEM, 2024)
	Average plant life remaining (years)	Integrated Resource Plan 2023 (DMRE, 2024) and Eskom, 2024
Sensitivity	Number of coal mine workers	SA Operating Mines dataset (Cole, 2024)
	Number of coal plant workers	Eskom Annual Report, 2023
	Number of mining services workers	Census 2011 (StatsSA, 2013)
	Number of industrial plants using coal	Own research
	Total coal mine worker income	Spatial Tax Data (SEADsa, 2024)
	Population in coal communities	Coal communities (Cole et al., 2023) and own research
Adaptive Capacity	Social wellbeing score	Census 2022 (StatsSA, 2024)
	Age dependency ratio	Census 2022 (StatsSA, 2024)
	Unemployment ratio	Census 2011 (StatsSA, 2012)
	Poverty ratio	Census 2011 (StatsSA, 2012)
	Economic diversity (industry share by employment)	Census 2011 (StatsSA, 2013)
	Municipal audit outcome	Municipal audit reports (AGSA, 2024)
	Type of municipality	National Treasury, 2024

The indicator selection process was guided by three key principles: 1) conceptual relevance to the components of vulnerability as defined in the transition literature; 2) data reliability and availability at the municipal level in South Africa; and 3) ability to capture the multidimensional nature of transition impacts beyond direct coal dependency (see Table 1). Local municipality was chosen as the relevant administrative level, rather than the town/community level, as it is difficult to assign specific coal assets (e.g., coal mines, coal plants) and associated jobs to individual communities/settlements especially since many cities, towns, townships, and villages are home to workers and businesses that are linked to more than one mine or plant.

2.1. Exposure to coal phase-down

Exposure is measured using five indicators – number of coal mines, total annual coal production, total 'life of mine' (years to closure based on coal reserves, market forecasts, technical, economic and environmental factors), total coal plant operating capacity, and total coal plant life remaining (based on the Integrated Resource Plan, IRP 2023 (DMRE, 2024), and an Eskom announcement in December 2024). Although these indicators are equally weighted, the greater number of indicators for coal mines compared to coal plants gives them greater weighting in the overall component and reflects the significantly greater number of mines compared to plants. The coal mining data are sourced from the South African operating mines dataset (Cole, 2024) and Global Coal Mine Tracker (Global Energy Monitor, 2024a), while the coal plants data are drawn from the latest Global Coal Plant Tracker (Global Energy Monitor, 2024b).

2.2. Sensitivity to coal phase-down

Sensitivity is measured using six indicators – number of coal mine workers, number of coal plant workers, number of mining services support workers, number of industrial plants using thermal coal, total coal mine worker income, and coal community population. The data for coal workers are based on recent figures published by mining companies or derived from estimates based on production. The number of coal plant workers per plant was estimated based on the published total number of Eskom workers in coal generation (Eskom, 2023) and the individual plant capacity (Global Energy Monitor, 2024). The number of mining services workers is drawn from the Census 2011 (StatsSA, 2013) which is quite outdated but the Census 2022 data (StatsSA, 2024) were not published at the local level at the time of analysis. Coal mine worker total income is sourced from the SARS tax data in the Spatial Tax dataset for 2023 and is calculated by multiplying the median income by the number of full-time employees as the actual total income is not reported (SEADsa, 2024). Population figures for coal communities are drawn from a detailed study on coal mining communities (Cole et al., 2023) and combined with data on coal plant communities taken from Census 2011. These data should be updated if/when the 2022 Census information for employment by sector is released. To the extent that the distribution of population across coomunities has remained stable over time, the CTVI results should not be affected by the use of Census 2011 data.

Data limitations require the assumption that workers at coal mines and plants reside in the same local municipalities as those in which they are employed. While this may not always be the case, particularly near a municipality's border, it is the most practical assumption given the current data constraints. Ideally, the Gross Value Add (GVA) of coal mining would also be included as a Sensitivity indicator, but the required data are not currently available.

2.3. Adaptive capacity

The adaptive capacity of communities in each municipality is shaped by social, economic and governance factors, including household incomes, employment levels, access to basic services, education levels and skills, access to healthcare, level of economic diversification, and local government capacity and effectiveness (Brooks et al., 2005; Cole et al., 2023; Roberts, 2016). Accordingly, adaptive capacity is measured using seven indicators related to age dependency, social wellbeing, employment, poverty, economic diversity, and local government audit outcomes.

Social adaptive capacity is assessed using four indicators – age dependency ratio, social wellbeing score, unemployment rate and poverty ratio. A lower age dependency ratio, a higher social wellbeing score, and lower unemployment and poverty ratios are generally associated with higher social adaptive capacity. Specifically, the age dependency ratio is the ratio of dependents (0–15 and 65+ years) to the working age population (15–65 years); thus a lower ratio indicates a lower vulnerability to job losses. The social wellbeing score, a multidimensional deprivation index covering ten indicators across three themes – basic services (water, sanitation, electricity, refuse removal), living standards (housing, household goods, internet access, car ownership) and education, is based on the South African Index of Multiple Deprivation, SAIMD (Cole et al., 2023; Cole and Broadhurst, 2021; Wright and Noble, 2009). Data for the social wellbeing score were sourced from the Census 2022 local municipality dataset published by Statistics South Africa (StatsSA) in 2024 and distributed by DataFirst (StatsSA, 2024). Further details on the social wellbeing score are given in the Appendix Table A1 and A2. The employment ratio is defined as the percentage employed of the total labour force, including discouraged jobseekers and the poverty ratio is the percentage of households below the upper-bound national poverty line. Both the employment and poverty ratios were calculated using the Census 2011 data as the Census 2022 data was not published at the time of the analysis.

Economic adaptive capacity is assessed using economic diversity and type of municipality, with the assumption that more diversified local economies will be more resilient to the coal phase down. Economic diversity is measured as the inverse of a Hirschman-Herfindahl index, based on local employment shares across industries, after (Roberts, 2016). For the purposes of the paper, the index is calculated using SIC

Table 2
Exposure indicators for all coal municipalities in South Africa.

Province	Municipality	No. of coal mines	Total mine production (Mtpa)	Combined Life of Mine (years)	No. of coal plants	Total coal plant capacity (MW)	Total years to plant retirement
Free State	Metsimaholo	1	16.3	36	1	3 708	17
	Ngwathe	1	1.6	30			
Gauteng	Emfuleni	1	16.3	36			
	Midvaal	1	16.3	36			
	Lesedi	1	0.2	20			
	Ekhuruleni	1	0.6	0			
	City of Tshwane	2	2.8	14			
KwaZulu-Natal	Endumeni	2	1.36	23			
	Newcastle	2	0.88	52			
	Emadlangeni	1	0.36	14			
	Dannhauser	1	0.32	20			
	Ulundi	1	0.75	4			
	Mthonjaneni	1	0.35	4			
	Mtubatuba	1	1.2	30			
Limpopo	Lephalale	1	17	54	2	8 790	65
Mpumalanga	Chief Albert Luthuli	1	1.5	2			
	Msukaligwa	4	5.8	5	1	1 600	1
	Mkhondo	2	0.4	38			
	Dr Pixley Ka Isaka Seme				1	4 143	27
	Lekwa	1	5.6	16	1	3 654	6
	Dipaleseng				1	600	3
	Govan Mbeki	7	43.9	111			
	Victor Khanye	9	19.7	65	1	4 800	49
	Emalahleni	24	105.1	293	4	13 716	46
	Steve Tshwete	18	34.4	94	2	3 752	6
	Emakhazeni	3	7.9	30			
	Thembisile	1	2.7	16			
	Nkomazi	2	0.9	19			

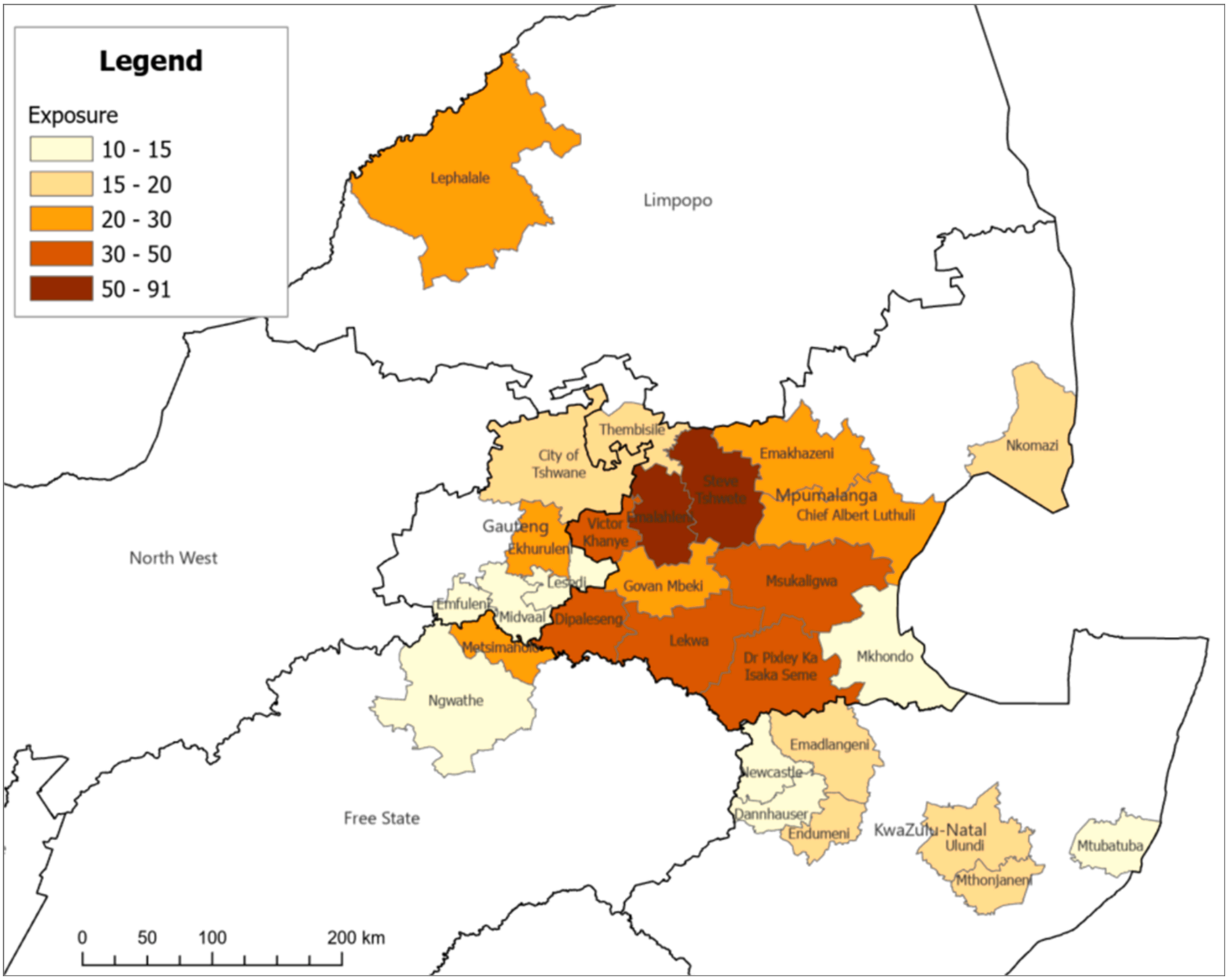

Fig. 2. Map of Exposure to the coal transition for all coal municipalities.

level 2 sectoral worker data for local municipalities in Census 2011. Type of municipality, as determined by the South African government, reflects the spatial geography of each municipality and the potential for economic diversification. Metros are Type A municipalities and local municipalities are categorised as B1 (secondary cities), B2 (large town as core), B3 (small towns with relatively small population) or B4 (mainly rural and at most 2 small towns). These categories were converted into rankings from 1 (B4) to 5 (A) for the measurement of economic adaptive capacity.

Governance capacity is assessed using the most recent financial performance audit outcomes for each local municipality in 2022/23 from the Auditor-General of South Africa (AGSA, 2024). The five audit categories, namely, 'unqualified audit with no findings (clean audit)', 'unqualified audit with findings' (the municipality struggled to produce quality performance reports and/or to comply with all key legislation), 'qualified audit with findings' (financial statements contained material misstatements and the municipality had challenges with the quality of the performance report and/or compliance with key legislation), and 'adverse audit' (the AGSA disagreed with virtually all the amounts and disclosures) and 'disclaimed audit' (the AGSA was unable to gather sufficient evidence to form an opinion), were converted into a rating from 1 (lowest adaptive capacity) to 5 (highest adaptive capacity).

The Governance Performance Index (GPI) for South African municipalities for 2024 was also considered but excluded to avoid duplication since it includes indicators for service delivery that are already included in the Social Wellbeing score. Further, the GPI also published the rankings for metros and local municipalities separately, rather than providing the actual scores for each municipality making direct comparison difficult.

Additional indicators for measuring 'regional resilience' or adaptability, such as innovation, experience of previous shocks, transferrable skills, willingness to change, and market opportunities, have been identified in the literature as important measures of resilience. These could be included in future iterations of the CTVI if and when relevant data were to become available.

Each component of the CTVI is calculated as an unweighted average of the indicators associated with the component, where the indicators are first normalized using the formula x' = (x - xmin) / (xmax - xmin), where x' denotes the normalized indicator, x the original indicator, and xmax and xmin the maximum and minimum values of the indicator respectively. The three components are then combined using the formula $CTVI_i = (E_i + S_i\ (100 - AC_i))/3$ where i indexes the local municipality, E is the exposure component of the index, S the sensitivity component, and AC the adaptive capacity component. The CTVI thus measures the vulnerability of each local municipality to coal phase-down scaled to range between 0 – 100 where 0 = "no vulnerability" and 100 = "highest vulnerability." Five categories for the overall CTVI were defined as Very low, Low, Medium, High, and Very high, based on

Table 3
Sensitivity indicators and index for all coal municipalities.

Province	Metro / Local Municipality	Coal mine workers	Mining support services 2023	Eskom coal plant jobs	Coal mine worker total income 2023 (ZAR)	Plants using coal as input	Coal communities' population in 2011
Free State	Metsimaholo	774	15	868	40 480	1	117 961
	Ngwathe	526	5		45 420		48 169
Gauteng	Emfuleni	2 012	267		47 388 810	1	500 000
	Midvaal	310	115		6 151 300	1	66 210
	Lesedi	25	85		15 797 320		121 610
	Ekhuruleni	353	8 253		37 474 245		121 610
	City of Tshwane	656	6 233		30 030 594	1	143 293
KwaZulu-Natal	Endumeni	458	17		4 279 044		52 502
	Newcastle	158	19		924 231	1	347 326
	Emadlangeni	320	5		8 907 393		5 290
	Dannhauser	314	5		525 822		22 600
	Ulundi	427	5		505 840		32 768
	Mthonjaneni	408	0		8 628 444		2 379
	Mtubatuba	1 600	5		3 380 300		16 641
Limpopo	Lephalale	7 319	64	2 058	179 404 362		58 631
Mpumalanga	Chief Albert Luthuli	50			7 803 092		16 846
	Msukaligwa	961	98	405	25 485 933		103 986
	Mkhondo	1 200	606		3 832 360		65 676
	Dr Pixley Ka Isaka Seme			1 049			60 810
	Lekwa	2 026		925	74 135 500		94 762
	Dipaleseng			152	134 125		5 415
	Govan Mbeki	7 460	5 766		142 483 569	1	283 765
	Victor Khanye	3 714	131	1 216	33 093 000		57 065
	Emalahleni	21 968	2 216	3 474	577 660 327	3	388 672
	Steve Tshwete	7 264	1 506	950	136 886 680	2	202 736
	Emakhazeni	997			6 253 976		16 625
	Thembisile	145			389 312		186 569
	Nkomazi	487	19		107 393		58 569

the range in CTVI scores.

3. Results

3.1. Exposure to the coal transition

The results for the exposure component of the CTVI are shown in Table 2 and Fig. 2, and described below. At present, there are 90 operating coal mines in South Africa, mostly located in the western part of Mpumalanga province, producing 235 Mt coal in 2024, with production output ranging from 0.32 Mtpa to 17 Mtpa at individual mines. Almost half the mines are in Emalahleni (24 mines) and Steve Tshwete (18 mines) local municipalities (LMs), producing 105 Mtpa and 34 Mtpa respectively, while seven coal mines in Govan Mbeki LM produce 44 Mtpa. The coal life of mine ranges from 0 to 57 years for individual mines, with Grootegeluk mine in Lephalale, Limpopo expected to close last in 2071. There are 14 coal power plants in South Africa operated by Eskom in three provinces – 11 in Mpumalanga, two in Limpopo and one in Free State just south of Gauteng. They range in age from eight years (Kusile) to 58 years (Camden) and retirement dates range from 2025 (Camden and Hendrina) to 2073 (Kusile). Exposure to coal phase-down is highest in Emalahleni and Steve Tshwete LMs, followed by Msukaligwa, Lekwa, and Dipaleseng LMs, all located in Mpumalanga province.

In summary, the spatial distribution of exposure reveals significant clustering in Mpumalanga province, which is reflective of the historical patterns of coal industry development shaped by geological factors, infrastructure investments, and corporate strategies. Notably, the concentration of both mining and power generation in certain municipalities creates compound exposure that amplifies transition challenges.

3.2. Sensitivity to the coal transition

The results for the sensitivity component are presented in Table 3 and Fig. 3. Coal mining jobs range from 60 to 3578 jobs per mine and from 25 to 21,968 jobs per municipality. Total jobs at Eskom coal-fired power plants range from 152 in Dipaleseng municipality to a maximum of 3474 in Emalahleni LM. Mining support services workers range from 5 to 8253 per municipality, based on the SARS tax dataset for 2023, although this is likely to be an undercount as support service workers may not be categorised under mining. Coal worker total income (median income multiplied by the number of full-time workers) spans a wide range from R40,480 per year in Metsimaholo LM in the Free State to R577,660,327 per year in Emfuleni LM in Gauteng.

South Africa has over 3 million people living in 134 coal communities, the latter defined as communities that house coal mine and plant workers, benefit from human resources and local economic development projects supported by the mines, or are located adjacent to a coal mine or coal-fired power plant. These coal communities are found across two metropolitan municipalities (Tshwane and Ekhuruleni) and 27 local municipalities, which together were home to over 12.8 million people in 2022.

In addition to the 14 coal fired power plants, Sasol's synthetic fuel plant in Secunda, Govan Mbeki in Mpumalanga province uses thermal coal as a direct input, while 16 mineral beneficiation plants across South Africa use metallurgical coal as a direct input for producing steel, ferrochrome and metal alloys. Although metallurgical coal is not under the same pressure to phase down as thermal coal, some mines produce both thermal and metallurgical coal, and the steel industry is under pressure to reduce its carbon emissions.

As illustrated in Fig. 3, sensitivity to coal phase-down is by far the highest in Emalahleni LM (a score of 84 out of 100) followed by Steve Tshwete LM (36) and Govan Mbeki LM (31). The least sensitive are the rural areas in KwaZulu-Natal and Free State provinces as well as other part of Mpumalanga with minimal direct coal activity.

The sensitivity analysis thus reveals complex patters of socio-economic dependence on coal that extend beyond direct employment. The higher wage premium for coal workers, especially compared to other sectors also means that each mining job supports multiple additional livelihoods through household sharing and local economic multipliers. This creates wider circles of vulnerability that need to be attended to.

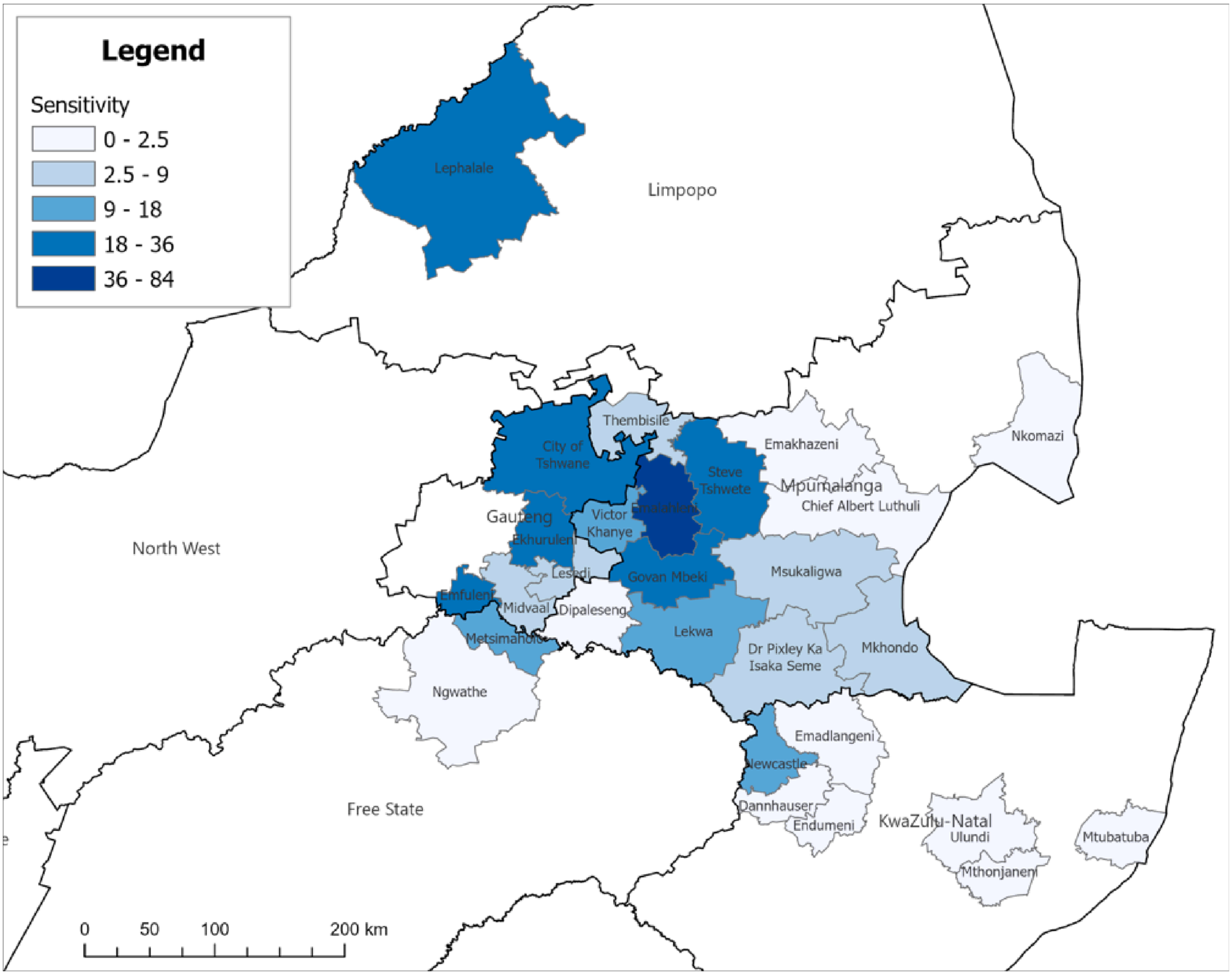

Fig. 3. Map of Sensitivity to coal phase-down for all coal municipalities.

3.3. *Adaptive capacity*

The results for the adaptive capacity component are shown in Fig. 4 and Table 4. The age dependency ratio (dependents to working age population) ranges from a low of 43 in Ekhuruleni metro, Gauteng, to a high of 77 in Ulundi LM, KwaZulu-Natal. The Social Wellbeing score, which reflects multidimensional deprivation with lower scores indicating higher deprivation, ranges from a low of 4.9 in Emadlangeni LM (most deprived) in KwaZulu-Natal to a high of 7.9 in Ekhuruleni metro (least deprived). The unemployment ratio ranges from a high of 65 % in Ulundi LM to a low of 22 % in Midvaal LM, Gauteng. The poverty ratio (share of households living below the upper-bound poverty line) ranges from a high of 60 % in Nkomazi LM to a low of 31 % in Steve Tshwete LM, both in Mpumalanga. Economic diversity, a proxy for the ability of local economies to cope with mine and plant closures, ranges from lows of 3.1 in Ulundi LM and 3.2 in Mthonjene LM in KwaZulu-Natal to highs of 7.1 in Msukaligkwa LM and 7.2 in Mkhonde LM, both in Mpumalanga. In terms of governace capacity, only one municipality had a clean audit in 2022/23 (Midvaal LM in Gauteng) while 12 received an unqualified audit with findings, 14 had a qualified audit with findings, and one (Emakhazeni LM) had an adverse audit.

Overall, as shown in Fig. 4, adaptive capacity is lowest in KwaZulu-Natal's rural areas, notably Ulundi (20), Mthonjaneni (26) and Mtubatuba (29) local municipalities, and highest in Steve Tshwete LM (81) in Mpumalanga and the two metros Ekhuruleni (82) and City of Tshwane (76) in Gauteng. These results indicate that metros and secondary cities demonstrate substantially higher adaptive capacity than rural municipalities, reflecting their more diversified economic bases, stronger institutional resources, and better service delivery performance.

3.4. *Coal transition vulnerability index*

The overall results for the CTVI are shown in Fig. 5 and Table 5. The highest levels of coal transition vulnerability are in Mpumalanga's Gert Sibande and Nkangala districts. Within these districts, Emalahleni LM stands out with the highest overall CTVI (score of 67) by a significant margin, followed by Steve Tshwete LM (39). Other highly vulnerable municipalities include Ulundi LM (34) and Mthonjaneni LM (31) in KwaZulu-Natal and Dr Pixley ka Isaka Seme LM (31) in Mpumalanga. In contrast, municipalities in Gauteng and the Free State have the lowest CTVIs are since they are not very dependent on coal mining. Notably, the LMs in KwaZulu-Natal have relatively high CTVI despite having few coal mines due to their very low adaptive capacities. This highlights the critical role of adaptive capacity in determining overall vulnerability.

4. Discussion

4.1. *Coal communities vulnerability to the transition*

The Coal Transition Vulnerability Index developed in this study

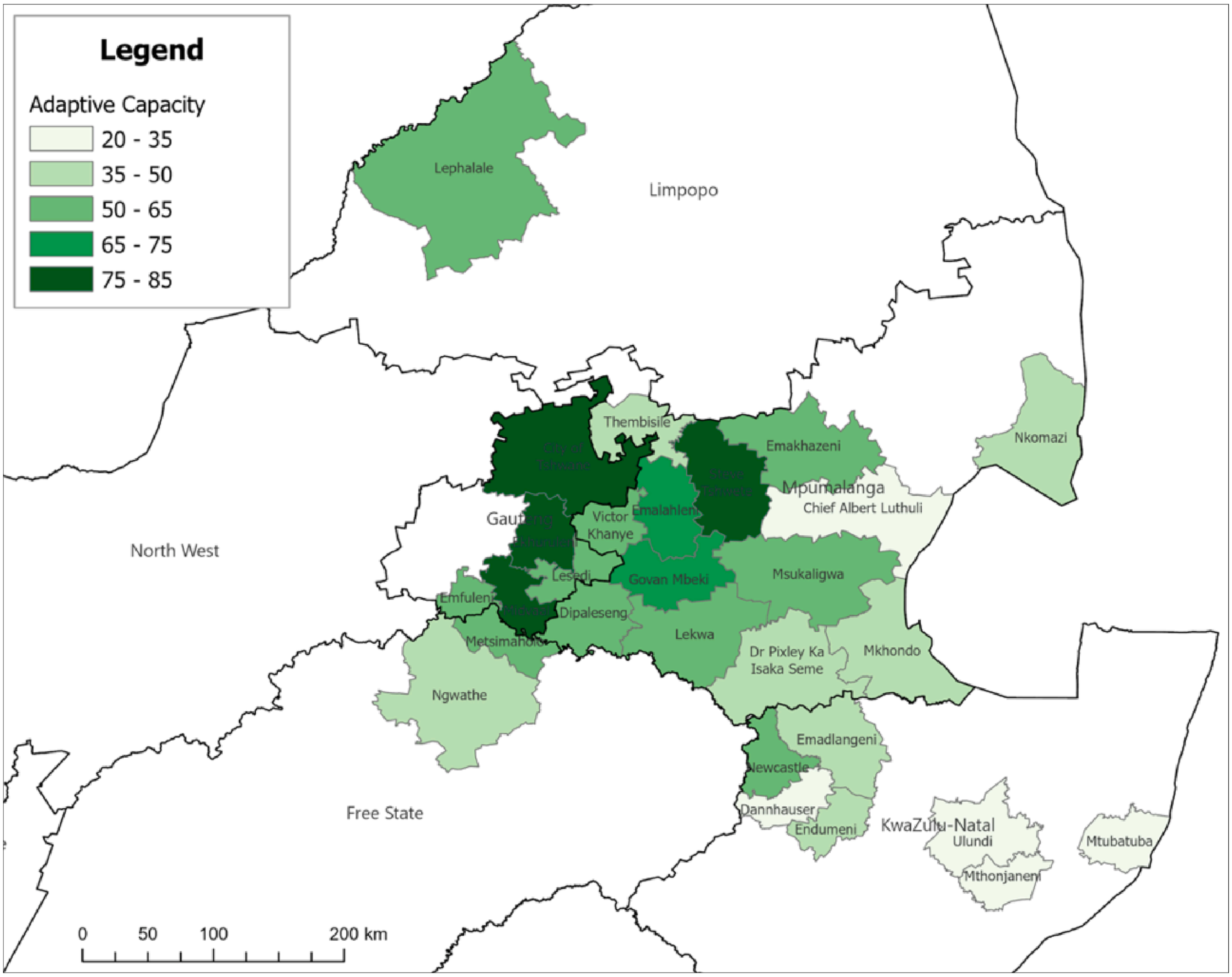

Fig. 4. Map of the adaptive capacity for all coal municipalities.

provides a useful tool for assessing the vulnerability of regions and communities, as countries, in this case, South Africa, transition away from coal to cleaner energy sources. Its three components— exposure, sensitivity and adaptive capacity—allow for nuanced assessments of potential impacts. The CTVI's strength lies in its ability to quantify and integrate these distinct dimensions: it considers not only the physical presence of coal infrastructure (exposure) but also gives significant weight to socioeconomic dependence, particularly coal-sector jobs and income (sensitivity), and accounts for the critical variations in the abilities of communities, local institutions, and economies to cope (adaptive capacity). This provides a much richer understanding than exposure alone.

South Africa has diverse coal communities encompassing secondary cities, towns, mining towns, townships, mine/plant villages, rural villages and informal settlements, that are spread across five provinces, 11 district municipalities, two metropolitan municipalities and 27 local municipalities, home to 12.8 million people. While the focus of the current just transition debates is rightly focused on Mpumalanga province due to its concentration of mines and plants, the CTVI analysis and vulnerability profiles presented in this study are an important reminder of the wider scope of the impacts that will affect the entire country.

The analysis presented in this paper highlights extreme spatial inequality in South Africa—not only in income, but also in access to basic services, living standards and livelihoods. Without appropriate policy actions to, most notably, improve adaptive capacity, the loss of coal jobs, many of which are low- to semi-skilled workers, may worsen existing inequalities, particularly in communities burdened by high unemployment and/or with high dependency on coal workers. On a positive note, the cities and urban areas in western Mpumalanga, where coal mining is concentrated also have the highest adaptive capacity and are better positioned to cope with the transition compared to the rural areas with only a few coal mines which have low adaptive capacity. Further, while the diversified economies of the cities will cushion the negative impact of the energy transition, many towns and villages are highly dependent on coal and will find it difficult to adapt, particularly having been established and developed because of coal mining that has been underway for over 150 years in South Africa. Specifically, Emalahleni and Steve Tshwete local municipalities are most vulnerable to the coal transition, and face severe economic challenges, with mining contributing approximately 40 % and 31 % of Gross Value Added (GVA) respectively (Montmasson-Clair et al., 2022).

While the CTVI is a standalone index with a narrow focus on the vulnerability of coal communities and regions, it has many indicators that directly link to the Sustainable Development Goals (SDGs). The Exposure indicators link to SDG 13 (Climate Action) while the Sensitivity indicators measure SDG 8 (Decent work), which is at risk from the energy transition. The Adaptive Capacity indicators measure several aspects of SDG 11 (Sustainable Cities and Communities), SDG 10

Table 4
Adaptive capacity indicators for coal municipalities in South Africa.

Province	Metro / Local Municipality	Age dependency ratio in 2022	Social Wellbeing Score in 2022	Unemployment rate in 2011	Poverty ratio in 2011	AGSA Audit score in 2023	Economic diversity in 2011	Type of municipality
Free State	Metsimaholo	54	7.7	35,1	39,9	3	5.3	B2
	Ngwathe	67	7.7	41,0	51,8	3	5.0	B3
Gauteng	Emfuleni	52	6.7	38,7	45,0	3	5.8	B1
	Midvaal	50	7.0	22,0	37,4	5	5.2	B2
	Lesedi	50	7.1	30,6	40,7	4	4.8	B3
	Ekhuruleni	43	7.9	32,3	38,5	4	5.4	A
	City of Tshwane	48	7.6	27,5	34,9	3	4.9	A
KwaZulu-Natal	Endumeni	56	7.3	33,5	56,5	3	4.4	B3
	Newcastle	58	7.6	46,5	50,8	4	5.6	B1
	Emadlangeni	65	4.9	49,4	46,1	4	5.5	B3
	Dannhauser	70	5.7	59,0	56,5	4	5.1	B4
	Ulundi	77	5.9	65,0	49,2	4	3.1	B4
	Mthonjaneni	75	5.2	41,3	54,6	4	3.2	B3
	Mtubatuba	71	5.7	50,1	52,3	3	4.5	B3
Limpopo	Lephalale	57	5.8	24,8	38,3	4	4.8	B3
Mpumalanga	Chief Albert Luthuli	65	5.9	46,4	57,1	3	6.5	B4
	Msukaligwa	51	6.4	33,0	41,3	3	7.1	B2
	Mkhondo	55	5.4	43,2	53,1	4	7.0	B3
	Dr Pixley Ka Isaka Seme	58	6.5	46,4	52,7	4	6.0	B3
	Lekwa	52	7.5	29,8	38,3	3	5.8	B3
	Dipaleseng	55	7.2	41,7	44,2	3	5.7	B3
	Govan Mbeki	51	7.8	29,8	37,8	3	6.0	B1
	Victor Khanye	48	7.1	33,6	42,4	3	6.9	B3
	Emalahleni	49	7.0	30,8	32,8	3	6.4	B1
	Steve Tshwete	48	7.7	23,4	30,9	3	6.5	B1
	Emakhazeni	50	7.2	31,7	41,4	2	5.4	B2
	Thembisile	61	6.1	44,6	49,4	4	5.6	B4
	Nkomazi	59	5.8	43,3	59,6	4	4.9	B4

(Reduced Inequalities), and SDG 16 (Strong Institutions). Adding disaggregated data for women and men would link to SDG 5, as has recently been done for coal workers (Cole et al., 2025). Overall, the CTVI supports an improved understanding of the many drivers of vulnerability and can therefore advance South Africa's progress towards the SDGs at national and sub-national levels. The CTVI could be included in the annual SDG monitoring reports, as a set of disaggregated, localized indicators for South Africa.

4.2. Policy responses and actions

The coal transition in South Africa is projected to be a gradual process, with the 90 coal mines and 14 power plants scheduled to close sequentially over the next five decades, presenting a window of opportunity for policy-makers and decision-makers to prepare and implement a proactive strategy and detailed plans. While the scale of the transition may seem overwhelming, the analysis in this study offers direction on key focus areas for government and donor agencies, especially from the perspective of place-based policies and targeted interventions. These focus areas should link to existing policy instruments such as the National Development Plan (NDP), the District Development Model (collaborative planning process undertaken at local, district and metropolitan level by all three spheres of governance resulting in a single strategically focussed One Plan), municipal five-year Integrated Development Plans (IDPs), and mining companies' five-year Social and Labour Plans (SLPs). The existing JET funding mechanisms – notably the JETP and municipal transition funds – should be used as vehicles for applying the CTVI, while the CTVI results could be used to inform budget and resource allocations determined through the Municipal Systems Act.

The findings of the analysis suggests that just transition projects and interventions cannot take a one-size-fits-all approach. Strategies must be tailored to the specific needs and vulnerability profiles revealed by the CTVI for each individual municipality and community, ensuring that the most vulnerable, whether vulnerable due to high exposure/sensitivity or low adaptive capacity, are prioritized and do not get left behind. The CTVI results could be included in the municipal IDPs and One Plans, and disaggregated to the town level, to inform medium-term planning. The existing programmes run by coal mining companies as part of their Social and Labour Plans (SLPs) cover skills training, job placements, local economic development, enterprise development, and are included in the local municipal IDPs. They could form a foundation for future just transition programmes, building on the relationships with communities, the financial investments, and the capacity building programmes. Qualitative research shows that many coal community members do not want the mines to close due to the jobs and services they provide (Ledger et al., 2024). The transition away from coal must consider the full extent of the contribution of mining to local communities and municipalities beyond jobs.

Specially, in high exposure areas, where mines and plants are due to close soon, collaboration with mining companies and Eskom plants need to be prioritized to build on existing training and local economic development programmes in coal communities. Mining companies already offer their permanent employees with options such as redeployment to other mines, retrenchment packages, early retirement options, reskilling programs and counselling services. However, specific attention and tailored support mechanism are needed for contract workers and those engaged in the informal economy. For high sensitivity areas more broadly, expanding the skills development programmes and facilities, improving secondary and tertiary education system to enhance their relevance to future economies, and enhancing infrastructure to support economic diversification, including transport connectivity and access to domestic and international markets, are critical. In terms of economic diversification, spatial scale matters; what is true at one scale might not be true at another scale and different factors carry varying importance. In areas with low adaptive capacity, strengthening local municipal capacity, is a priority. This includes capacity building support to local municipalities to improve basic services, revenue collection and

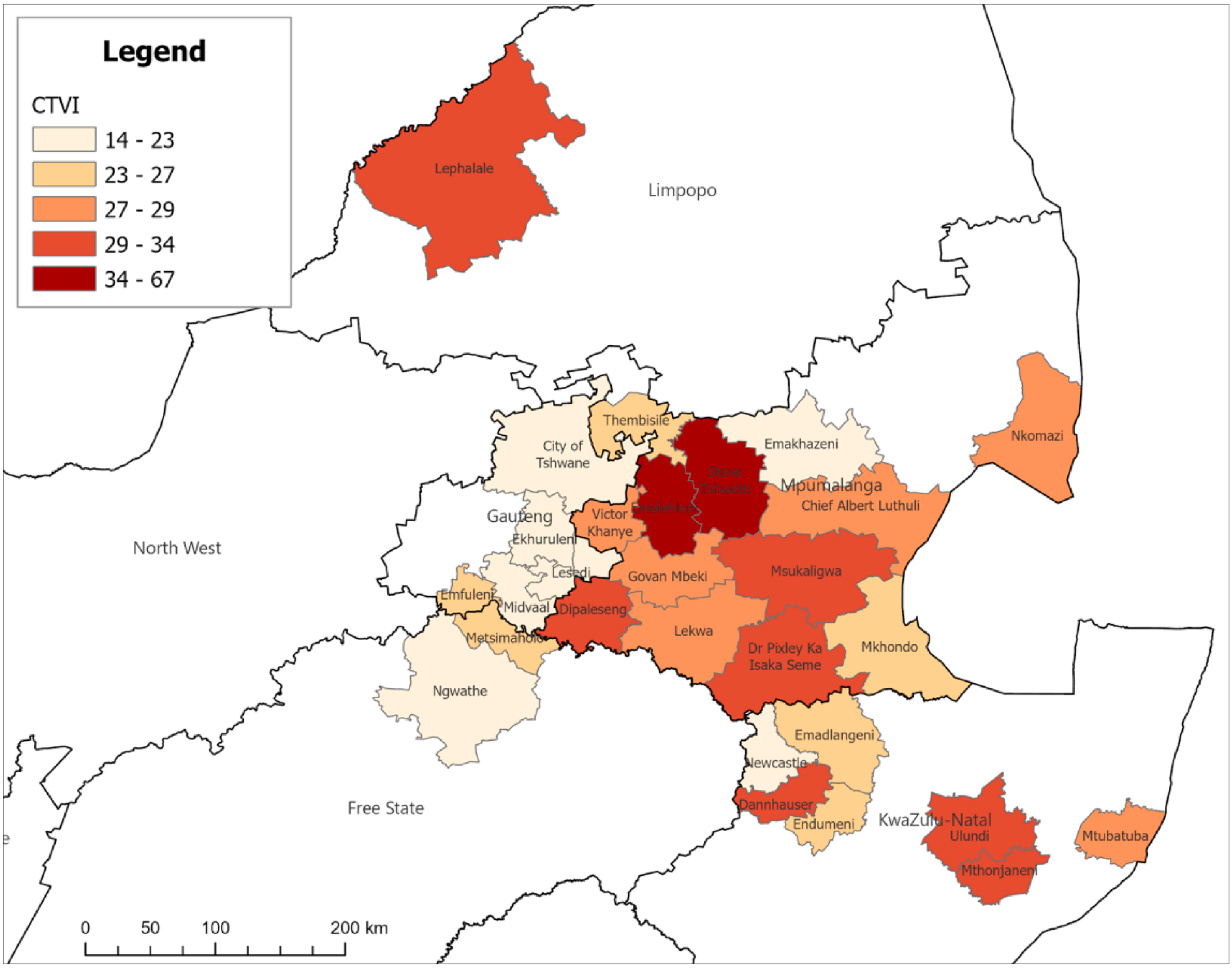

Fig. 5. Map of the Coal Transition Vulnerability Index (CTVI) for all coal municipalities.

develop just transition project pipelines as has been initiated in Steve Tshwete LM.

The governance dimensions of transition vulnerability emerge as particularly significant in the CTVI analysis, where municipalities with stronger institutional capacity, as reflected in audit outcomes and service delivery performance, demonstrate greater potential to manage transition challenges effectively. However, most coal municipalities are already facing serious financial, administrative and performance management risks. The majority have poor audit outcomes, and in 2022, an estimated ZAR 17 billion was considered unauthorized, irregular, fruitless and wasteful expenditure (National Treasury, 2024). This raises critical concerns—if municipalities are struggling despite the current support availed through coal mines and plants, the outlook is not good for post-closure and decommissioning. Research already points to deterioration of services and local economies in towns and villages in South Africa that have experienced mine closure (Marais, 2013; Marais et al., 2021; Marais and Nel, 2016; Nel et al., 2023). Proactive, inclusive and well-coordinated action is therefore essential to achieving a just transition that will prevent further decline as well as promote sustainable alternatives. This will not be possible without a significant collaborative effort on the part of the national government, provincial government, local government, mining companies, labor unions, civil society and the communities themselves.

4.3. Intra-community vulnerability

While the CTVI provides valuable insights at the municipal level, it necessarily treats municipalities as relatively homogeneous units, masking significant intra-community heterogeneity described in Cole et al. (2023). Qualitative research reveals that within communities identified as vulnerable by the CTVI, certain groups face disproportionate challenges that require specific policy attention. Specific demographic groups such as women, youth, black communities grappling with historical land injustices, and informal workers face unique and amplified risks during the coal transition (Ledger et al., 2024). Women experience compounded vulnerabilities stemming from pre-existing gender inequalities, including impacts on social service access, increased care burdens, heightened exposure to gender-based violence, and exclusion from planning processes. Youth in coal-dependent regions confront significant hurdles related to skills mismatches, inadequate educational pathways, and systemic unemployment, despite emerging skills development programs. For black communities, the transition intersects deeply with legacies of apartheid, particularly concerning land dispossession and environmental degradation, demanding that mine closure, rehabilitation, and repurposing processes actively address historical harms through meaningful community participation and co-production – a currently deficient area. Informal workers, often invisible in formal planning, face direct threats to their livelihoods and require targeted social protection and integration strategies.

Table 5
CTVI and its components for all coal municipalities in South Africa.

Municipality	District / Metro	Province	Exposure	Sensitivity	Adaptive capacity	CTVI	
Emalahleni	Nkangala	Mpumalanga	91	84	74	67	Very high
Steve Tshwete	Nkangala	Mpumalanga	64	36	81	39	
Ulundi	Zululand	KwaZulu-Natal	19	1	20	34	High
Mthonjaneni	Uthungula	KwaZulu-Natal	19	1	26	31	
Dr Pixley Ka Isaka Seme	Gert Sibande	Mpumalanga	35	7	49	31	
Lephalale	Waterberg	Limpopo	24	23	56	30	
Msukaligwa	Gert Sibande	Mpumalanga	46	7	64	30	
Dannhauser	Amajuba	KwaZulu-Natal	13	1	27	29	Medium
Dipaleseng	Gert Sibande	Mpumalanga	40	1	54	29	
Lekwa	Gert Sibande	Mpumalanga	39	11	63	29	
Chief Albert Luthuli	Gert Sibande	Mpumalanga	20	1	34	29	
Nkomazi	Ehlanzeni	Mpumalanga	18	2	35	29	
Govan Mbeki	Gert Sibande	Mpumalanga	28	31	74	28	
Victor Khanye	Nkangala	Mpumalanga	36	12	64	28	
Mtubatuba	Umkhanyakude	KwaZulu-Natal	10	2	29	28	
Metsimaholo	Fezile Dabi	Free State	29	14	62	27	Low
Thembisile	Nkangala	Mpumalanga	15	6	53	26	
Emadlangeni	Amajuba	KwaZulu-Natal	16	1	39	26	
Emfuleni	Sedibeng	Gauteng	11	26	60	25	
Endumeni	Umzinyathi	KwaZulu-Natal	18	2	46	25	
Mkhondo	Gert Sibande	Mpumalanga	15	5	49	23	
Newcastle	Amajuba	KwaZulu-Natal	12	17	61	24	
City of Tshwane	City of Tshwane	Gauteng	20	25	76	23	Very low
Ngwathe	Fezile Dabi	Free State	10	2	45	22	
Emakhazeni	Nkangala	Mpumalanga	20	1	58	21	
Ekhuruleni	Ekhuruleni	Gauteng	21	22	82	20	
Lesedi	Sedibeng	Gauteng	13	5	62	19	
Midvaal	Sedibeng	Gauteng	11	8	76	x	

Therefore, based on the heterogeneity of vulnerability within communities, policies must be tailored to address the specific challenges faced by different demographic groups. For women, this means ensuring gender-responsive transition planning that accounts for both direct employment effects and broader social service impacts. For youth, dedicated educational pathways and entrepreneurship opportunities that offer viable alternatives to mining careers are essential. For black communities, transition planning must address historical injustices related to land rights and ensure meaningful participation in land rehabilitation and repurposing decisions. For informal workers, expanding social protection coverage and creating pathways to formalization will be critical to prevent deepening precarity. The combination of the quantitative CTVI framework with qualitative research offers a more comprehensive understanding of vulnerability that acknowledges both spatial patterns and social differentiation. This integrated approach reveals that vulnerability is not merely about geographic proximity to coal mining activities, but is fundamentally shaped by intersecting social categories including gender, race, age, employment status, etc.

While the vulnerability framework necessarily focuses on potential negative impacts, it is important to recognize that transitions also create opportunities for positive transformation. Municipalities with high exposure but also high adaptive capacity may be well-positioned to develop new economic activities in renewable energy, mine rehabilitation, or alternative industries that leverage existing skills and infrastructure. Identifying and cultivating these opportunities requires proactive planning and investment rather than reactive responses to coal industry decline.

4.4. Future research

While this paper advances the just transition discourse in South Africa by developing a context-specific Coal Transition Vulnerability Index (CTVI), several key areas require further research to deepen understanding and inform more effective policy and programmatic responses. Municipal-level analysis inevitably obscures intra-municipal variations in vulnerability, which may be significant, particularly in larger or more diverse municipalities. To address this, efforts should focus on exploring disaggregated data or conducting qualitative research to capture these variations more accurately. Data limitations—especially regarding informal economic activities and social networks—may result in certain dimensions of vulnerability being underrepresented. Further research should examine the impacts of these informal activities and networks to provide a more comprehensive assessment. Additionally, the equal weighting of indicators is a simplifying assumption that could be refined through sensitivity analysis in future studies to improve the robustness of the index. This analysis could result in uncertainty ranges being included for the composite scores.

The current analysis incorporates economic diversity within the adaptive capacity component of the CTVI. Further work is needed to assess the degree to which current economic diversity, factored into the adaptive capacity score, is dependent on coal mining and processing. When a mine or plant closes, industries and services associated with the mine or plant also face decline, even closure. Since a high level of diversity may mask these vulnerabilities, future research should aim to disentangle diversity that is unrelated to the coal industry (i.e., no direct input-output linkages) from diversity that is related. There is also scope to expand or complement the economic diversity indicator with an Economic Potential Index, EPI, composed of a set of relevant indicators that measure availability of natural endowments, access to infrastructure, and agglomeration factors (Roberts, 2016).

Successful mine closure processes require consideration of long-term impacts and interventions, however very few studies assess outcomes of efforts to reorient coal mining regions and revitalize mono-industry towns (World Bank Group, 2018). There is a current narrative and assumption in South Africa that local economic diversification is possible with enough financial resources, however research indicates that spatial structure changes very slowly (Lin and Rauch, 2022), historically mining hinders entrepreneurship and urban growth in trade, services and finance (Glaeser et al., 2015) and migration of skilled workers from mining towns and villages to the cities are likely (Alexander, 2010; Cole and Broadhurst, 2022; Godsell, 2011; Marais et al., 2023, 2017; Storey, 2016). Further research is needed on the historical and current evolution of South Africa's coal communities, their local economies and migration and population growth patterns, and the potential pathways for economic diversification and/or economic transition. Lessons can be learned from the experience in KwaZulu-Natal during and after the coal mine closures of the 1980s and 1990s where limited research shows some success in the secondary city of Newcastle (Marais et al., 2021; Nel et al., 2023) but significant challenges in the small towns (Binns and Nel, 2003) and rural villages (Nel and Mabale, 2024) and from the closure of gold mines in Gauteng, North West and Free State provinces. Policies and plans by national and provincial governments need to consider how best to support the affected communities using evidence and lessons from past and current experience.

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CRediT authorship contribution statement

Megan J. Cole: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ezgi Canpolat:** Writing – review & editing, Project administration, Funding acquisition, Conceptualization. **Mark Roberts:** Writing – review & editing, Methodology, Conceptualization. **Bandita Sijapati:** Writing – review & editing, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

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Appendix

Social Wellbeing indicators and data from Census 2022

Table A1
Basic services in coal municipalities, for persons, 2022, as percentage of persons.

Local /Metro municipality	Formal dwelling	Electricity as main source for lighting	Electricity as main source for cooking	Piped water in dwelling or yard	Access to toilet	Refuse removal
Chief Albert Luthuli	91	95	66	77	29	15
Msukaligwa	78	82	58	76	71	63
Mkhondo	83	87	46	67	41	31
Pixley Ka Seme	85	86	65	86	64	57
Lekwa	86	93	89	91	89	73
Dipaleseng	87	89	85	89	88	81
Govan Mbeki	86	92	93	93	92	88
Victor Khanye	84	91	81	86	79	74
Emalahleni	88	84	88	81	78	66
Steve Tshwete	89	91	87	84	84	84
Emakhazeni	92	91	67	92	88	80
Thembisile Hani	95	97	93	78	12	25
Nkomazi	97	96	83	66	15	16
Metsimaholo	90	93	94	95	91	85
Ngwathe	90	95	96	94	89	92
Emfuleni	10	91	96	97	95	44
Midvaal	6	93	96	94	96	84
Lesedi	4	95	95	97	97	93
Ekhuruleni	88	94	95	94	94	91
City of Tshwane	85	91	93	91	79	80
Endumeni	94	88	85	84	78	73
Newcastle	96	97	96	96	70	66
Emadlangeni	77	64	50	54	32	21
Dannhauser	84	95	83	65	16	9
Ulundi	80	98	86	65	34	17
Mthonjaneni	67	96	74	47	41	15
Mtubatuba	92	97	88	38	34	9
Lephalale	91	96	59	62	33	30

Table A2
Living standards in coal municipalities, percentage of households or adults, in 2022.

Local municipality	Fridge ownership	Internet access	Car ownership	Education level Grade 12 or NQF4 or higher
Chief Albert Luthuli	70	78	21	46
Msukaligwa	60	79	24	46
Mkhondo	63	71	18	39
Pixley Ka Seme	67	77	23	43
Lekwa	74	81	29	46
Dipaleseng	61	83	22	38
Govan Mbeki	72	87	29	50
Victor Khanye	66	81	24	41
Emalahleni	58	82	27	53
Steve Tshwete	71	86	34	58
Emakhazeni	61	80	23	48
Thembisile Hani	70	77	23	46
Nkomazi	73	74	21	43
Metsimaholo	71	76	25	50
Ngwathe	74	75	22	47
Emfuleni	67	86	24	55
Midvaal	57	86	34	58
Lesedi	67	82	27	50
Ekhuruleni	61	86	26	59
City of Tshwane	62	86	31	64
Endumeni	65	82	28	55
Newcastle	73	87	26	58
Emadlangeni	45	82	24	38
Dannhauser	72	83	20	43
Ulundi	71	81	19	45
Mthonjaneni	66	74	12	34
Mtubatuba	73	78	20	44
Lephalale	59	78	22	46

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