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To cite this article: Katherine Davidson, Joanna Grotte, Arindam Jana, Ariane De Lannoy, Anda David & Murray Leibbrandt (10 Apr 2026): An analytical framework to assess green transition jobs in South Africa, Climate Policy, DOI: [10.1080/14693062.2026.2654965](https://doi.org/10.1080/14693062.2026.2654965)

To link to this article: <https://doi.org/10.1080/14693062.2026.2654965>



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An analytical framework to assess green transition jobs in South Africa

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ABSTRACT

Climate change and the resultant catastrophic weather events across the globe underpin the need for a shift away from carbon-intensive modes of production. In South Africa, where electricity generation is heavily reliant on coal, this imperative is recognised, and various policies aim to support the implementation of a Just Energy Transition. The transition to a greener economy can have various impacts on the labour force, with a significant concern being an increase in unemployment. In this paper, a Green Transition Framework is proposed for profiling workers who are likely to be impacted by the energy transition, based on what work they do and in which industry they work. By combining a bottom-up approach that identifies green transition related occupations, with a top-down approach that identifies 'brown' industries, a matrix is developed that allows us to examine where on the nexus between 'green transition occupations', and brown industries, workers find themselves. Using South African labour force data, these dimensions are plotted to provide a picture of the type of worker who may be at risk of, or alternatively, may be better placed to withstand the potential effects of the green transition. This can ultimately assist in developing effective policies and interventions to mitigate the risks of the green transition. Key features of the Framework are its flexibility with respect to the definition of 'green' occupations and 'brown' industries; the integration of bottom-up and top-down methodologies; as well as the data utilised. Such a Framework can be broadly applied in global contexts other than South Africa.

Key policy insights

- The Green Transition Framework integrates industry and occupation information, both of which need to be considered in the creation of targeted policies and intervention strategies concerning the green transition and the labour market.
- The bottom-up and top-down approaches that are introduced allow for nuanced analysis of green jobs in South Africa, which is essential for evidence-based policy.
- The Framework can be tailored to specific research contexts, and is flexible in the methodologies for estimating green employment and brown industries, making it a globally applicable analytical tool.
- Two preliminary applications of the framework suggest that workers in polluting industries may have transferable skills for the green economy and that men may find it easier to transition to green jobs. Such findings can assist in more nuanced policy development.

ARTICLE HISTORY

Received 30 June 2025

Accepted 31 March 2026

KEYWORDS

Green transition; just energy transition; green occupations; carbon emissions; brown industries; O*NET green occupations

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Supplemental data for this article can be accessed online at <https://doi.org/10.1080/14693062.2026.2654965>.

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1. Introduction

The imperative to transition towards a greener economy that is less reliant on fossil fuels is globally recognised (European Environment Agency, 2024; US Environmental Protection Agency, 2024). South Africa's heavy reliance on coal makes it one of the largest global greenhouse gas emitting countries, highlighting both the importance of, and the difficulties related to, achieving a green economic transition in the country (Burton et al., 2018). While South Africa has many ambitious policies in place that aim to support the transition, implementation has been slow (Amis et al., 2018). Plans and policies include the Just Economic Transition Investment Plan (JET IP) 2023–2027 and the Just Economic Transition Implementation Plan 2023–2027 (The Presidency, Republic of South Africa, 2023a, 2023b). The JET Investment Plan lays out the investment needed between 2023 and 2027 to meet South Africa's commitment to achieving the National Determined Contribution target range of 350–420 Mt CO₂ by 2030. The JET Implementation Plan 2023–2027 sets out the actions required within the period to meet this commitment, to be implemented in a manner that delivers just outcomes for the people affected by the energy transition.

A transition to a greener economy entails significant impacts on employment. In a country such as South Africa, which experiences high rates of poverty, inequality and unemployment, the issue of job losses requires careful consideration. While mitigating the impact of a potential increase in unemployment resulting from the green transition is a core principle of the Just Energy Transition mandate (The Presidency, Republic of South Africa, 2023a, 2023b), the effective design and implementation of policies and strategies in line with this requires detailed information and statistics on the labour market. It is important to understand which workers will be affected by the transition, as well as how they will be affected. To address this need, our paper provides a Framework for analysing and contextualising the potential employment effects of the green transition. This is done by profiling workers who are likely to be affected by the transition based both on their occupation (what they do), and the industry in which they work (supplying what product).

The paper introduces three distinct methodologies for measuring and analysing green employment and is structured as follows: Section 2 outlines a bottom-up approach to estimating 'green' jobs which exploits occupational data. The Occupational Information Network (O*NET) defined green occupations are used, referred to here as 'green transition' occupations, as they are occupations that are associated with, and will potentially be impacted by, the green transition. As part of the approach, a new method for applying international occupational information to the South African context is developed. This method is applied to data from the 2019 Labour Market Dynamics Survey to derive national estimates of 'green transition' employment.

Section 3 details a top-down approach, focused on quantifying 'green jobs' based on industry. This analysis utilises carbon emissions data to profile workers based on the 'brownness' of the industry in which they work. Two measures underpin this analysis, namely pollution intensity and emissions intensity. Pollution intensity reflects the extent to which the worker contributes to total carbon emissions in the country, as determined by the industry they work in. Emissions intensity represents the carbon emissions efficiency, or lack thereof, of workers in their respective industries. It can be understood as the carbon footprint of each worker.

Section 4 introduces the Green Transition Framework which brings together the top-down and bottom-up approaches detailed above. The Framework integrates both elements to analyse the potential effects of the transition to a greener economy. A key feature of the Framework is its flexibility, which broadens its applicability beyond the South African context. A worked example illustrates the application of the Framework to a specific research question using South African data. The final section concludes by looking ahead to future work.

2. The bottom-up approach: estimating green occupations

2.1. Bottom-up methodology

There are two leading methods used to estimate green occupations applying the bottom-up approach:

- (1) Occupational greening: utilises definitions of green occupations to assess the impact of the green transition on an occupation (Dierdorff et al., 2011).

- (2) Green task intensity: measures the extent to which a worker performs green tasks, and captures the effect that occupations have on the environment.¹

The key focus of this paper is the employment effects of the green transition, rather than the impact of an occupation on the environment. As a result, an occupational greening approach to identifying green employment is taken.

The most widely used classification system in bottom-up approach research regarding green occupations is the O*NET's Green Economy Program, of the United States Department of Labour, which identifies green occupations within the O*NET system. Research conducted by Dierdorff et al. (2009) forms the basis of this green occupation identification. The authors define three occupational categories which highlight the varied effects that the greening of the economy can have:

(A) Green Enhanced Skills Occupations (GES)

These are existing occupations that are expected to see a significant change to their task content and worker requirements, but may not necessarily see an increase in employment demand due to the green transition. An example is architects. In moving to a greener economy, the construction of buildings must switch to more environmentally friendly models, and architects will likely need new skills or knowledge to implement these greener models.

(B) Green Increased Demand Occupations (GID)

These are existing occupations that are expected to see an increase in employment demand due to the green transition, without the need for significant changes to their task content or worker requirements. An example is bus drivers. The green transition will lead to a greater reliance on public transport as people reduce their use of private vehicles. Thus, bus drivers may be in greater demand, but they are not directly involved in reducing the carbon emissions of the economy.

(C) Green New and Emerging Occupations (GNE)

These are new occupations created due to the unique needs of the green transition. An example is Chief Sustainability Officers who 'communicate and coordinate with management, shareholders, customers, and employees to address sustainability issues' (O*NET, 2025). This occupation would likely not exist if not for the need to transition to a greener economy.

Dierdorff et al.'s (2011) occupational greening approach has been used in studies on employment outcomes of green transitions. Bowen et al. (2018), and Bowen and Hancke (2019) apply it to analyse job impacts in the United States and European Union. They find 19.4% of US employment and 35.5% (2006) to 40% (2016) of EU employment in green occupations. Valero et al. (2021) report that 17% of employment in the United Kingdom is in green occupations in 2019. A similar approach is taken by Becerra et al. (2024) and De La Vega et al. (2024), who estimate that approximately 22% of workers in Colombia and between 23% and 25% in Argentina are employed in green jobs.

Few studies have explored green jobs in South Africa, and none use the occupational greening method. Bhorat et al. (2024) focus on the jobs at risk in the coal mining sector and highlight that coal mining employment represents only 0.5% of total employment. The World Resources Institute (2021) found that approximately 200 000 workers are employed in coal mines, coal power plants and coal transport, putting them at risk. Makgetla et al. (2019) consider five areas that may be impacted by the transition: coal value chain, metals value chain, petroleum-based transport, agriculture and tourism. The authors stress that employment vulnerability might be low at the national level, but very high in the municipalities where coal mining or coal plants are concentrated. Mosomi and Cunningham (2024) apply a task-based approach to South African data, adjusting Granata and Posadas (2024) green terms dictionary for local relevance. They define green occupations as either 'strict', with tasks directly linked to the environment, or 'broad', with tasks that could reduce

environmental harm if green technology were adopted. Using this, they find that 5.5% (strict) and 32% (broad) of jobs in South Africa are green. Their method gives all 4-digit occupation codes the same green task intensity, potentially overlooking task diversity within these codes.

Thus, green occupations are identified as per O*NET's lists of 'green transition occupations' and codes. Thereafter, several steps are required in the application of these codes to South African data. Occupational Classification Systems are systems of codes allocated to different occupations, of which South Africa uses two.² The Organising Framework for Occupations (OFO) is developed and maintained by the Department of Higher Education and Training, while the South African Standard Classification of Occupations (SASCO) is created and maintained by Statistics South Africa. There are two major differences between these systems. First, the OFO is based on the newer 2008 version of the International Standard Classification of Occupations (ISCO), whereas the SASCO is derived from 1988 version. Second, the OFO provides granular occupation information down to the 6-digit level, while the SASCO's most detailed categorisation extends only to the 4-digit level. The OFO system's 6-digit classification level is comparable to the 8-digit level of the O*NET green occupations, albeit somewhat less granular. This allows for a near one-to-one match between these classification systems. The OFO, however, is not used in South African labour market data to identify occupations, which instead rely on the SASCO classification system. Thus, any quantitative research using the bottom-up approach needs to be able to identify green occupations in terms of the SASCO system.

In brief, this involved the following steps:³

- (1) Match the O*NET green occupations, as per the three lists described above, to the 6-digit OFO classification system, via a crosswalk developed for this paper.⁴
- (2) Aggregate the 6-digit OFO occupation classifications to the 4-digit level, resulting in an 'occupational greenness' measure, which is the proportion of 6-digit green occupations at the 4-digit level.
- (3) Crosswalk the 4-digit OFO classifications to the 4-digit SASCO codes so they can be identified in the survey data.⁵
- (4) Calculate the number of workers in 'green transition occupations' by applying the proportions calculated in step 2 to household survey employment data.

One of the major implementation difficulties facing any bottom-up approach in South Africa is the reliance on outdated occupation classification systems. Occupations in South African labour market data are identified using the 2003 version of SASCO which is based on the ISCO 1988. This means that occupations that have emerged more recently cannot be captured in labour market data. Moreover, occupations are identified at a 4-digit level, which means that each code represents many occupations. It is thus necessary to assume that employment is equally distributed across all the 6-digit occupations aggregated under the 4-digit codes, as further disaggregated employment data is not available. While this assumption is made by many other authors in occupation related research, it does reduce the accuracy of the final employment estimates.

Another challenge arises from the dependence on international green occupation data. The O*NET lists of 'green transition occupations' and their associated green task information were developed in 2010 for the United States labour market. This means that newer occupations, as well as those only relevant in the South African context, will not be captured. There is also a risk that the O*NET lists identify occupations that do not exist within the South African context. However, matching the O*NET green occupations to the OFO occupation codes helps to lessen the likelihood of an occupation not existing in the South African context.

Lastly, an occupation's greenness is consistent across industries and geographies. This will be true irrespective of the green occupation definition used. For example, a logistics manager in mining in Mpumalanga will have the same 'greenness measure' as a logistics manager in agriculture in the Western Cape, as their occupation codes are the same despite being employed in different industries. There may be differences in skill level or even specific job tasks in different geographies, or within different industries, which cannot be accounted for. This limitation of the bottom-up methodology highlights the usefulness of combining the approach with the top-down approach to identifying brown industries.

Table 1. Green transition employment, 2019.

	Green Transition Employment	Proportion of Total Employment
Green Enhanced Skill (GES)	576 998	3.5%
Green Increased Demand (GID)	760 312	4.6%
Green New and Emerging (GNE)	161 569	1%
Total Green Transition Employment (adjusted)	1 442 936	8.7%
Total Employment	16 570 766	100%

Note: the employment in the three categories of green transition employment cannot simply be added together to calculate *total* green transition employment, as some of the 4-digit occupations appear in more than one of the lists. Adding the three categories together would thus result in double counting, and some adjustment is required to prevent this.

Source: Own calculations using data from the Labour Dynamics Survey 2019 (Statistics South Africa, 2019).

2.2. Estimating green transition employment in South Africa

This section provides estimates of employment in the ‘green transition occupations’, using 2019 Labour Market Dynamics data (Statistics South Africa, 2019). Table 1 shows the number of workers in each ‘green transition occupation’ category, as well as this employment as a percentage of total employment. Green Increased Demand (GID) represents the highest proportion of total employment at 4.6%. This indicates that 4.6% of workers are employed in occupations that are expected to see an increase in demand due to the green transition. Workers in these occupations are employed in occupations that can support green activities. Green New and Emerging (GNE) represent the smallest proportion of workers, with only 1% of workers employed in occupations created entirely due to the needs of the green economy. This low proportion is supported by the findings of Amis et al. (2018) that South Africa has not made significant progress toward a greener economy. Green Enhanced Skill (GES) occupations are those that are expected to see a change in their task content and worker requirements because of the green transition, with 3.5% of workers employed in these occupations. In total, approximately 8.7% of all workers are employed in ‘green transition occupations’.

Valero et al. (2021) found a similar share of GID employment in the United Kingdom. However, they found much higher shares of GNE (5%) and GES (7%) employment. The GNE share found here is similar to that found for the United States by Bowen et al. (2018) however, the United States has much higher shares of the other two categories. Bowen and Hancke (2019) found estimates for the European Union that are much higher than those found here or in either study mentioned above. They found 22.5%, 20% and 17.4% shares for GID, GES and GNE, respectively. These higher shares are likely the result of a more generous approach to mapping O*NET green occupation codes onto the ISCO-08 codes (Bowen et al., 2018; Bowen & Hancke, 2019; Valero et al., 2021). Using a different bottom-up methodology, Mosomi and Cunningham (2024) find that 5.5% of South Africa’s workers are employed in occupations linked to the environment. This figure is comparable to that reported for GES and GNE occupations, both of which encompass green tasks and can therefore be interpreted as positively associated with the green transition. The comparatively lower values observed for GNE and GES occupations are likely attributable to the fact that each category represents only a subset of the broader range of occupations classified as strictly green by Granata and Posadas (2024).

3. The top-down approach: estimating the pollution intensity of industrial sectors

The top-down approach provides an environmental profile of employment based on industry. This approach is pursued using two main methodologies: one aimed at identifying green jobs and the other focused on brown jobs. Both methodologies assume that all workers within brown or green industries are engaged in green or brown employment, irrespective of their occupation.

Green industries are typically defined based on their output or production processes. For instance, renewable energy industries are frequently classified as green (International Renewable Energy Agency and International Labour Organisation, 2023; Thomas, 2022). Another common method is to define green industries as those producing environmental goods and services (Becker & Shadbegian, 2009; Elliott & Lindley, 2017; Eurostat, 2024). However, a key limitation of this method is that many of these producers also manufacture non-green goods, and there is often insufficient data to differentiate between them. Additionally, the lack of

consistent data makes it difficult to compare the results of this method across countries (OECD, 2023). The application of these methodologies to South Africa remains challenging due to insufficient granular data.

Accordingly, this paper focuses on the strand of the literature devoted to identifying 'brown' jobs, or jobs that harm the environment. Most often these methodologies utilise emissions data to place the industry on a spectrum from green to brown. This paper utilises two measures: *emissions intensity* measures the carbon emissions per worker for each industry, while *pollution intensity* considers the proportion of total carbon emissions contributed by each industry. Both identify 'brown' industries as those with higher intensity (Bluedorn et al., 2022; Vandeplas et al., 2022). EXIOBASE 3 emissions data is used to estimate these measures for South Africa, discussed in more detail below.

The costs associated with climate change have been part of economic literature for a few decades, most notably pioneered by Nordhaus, who introduced the concept of integrated assessment models (IAMs) (Nordhaus, 2019, 1977, 1991). These models typically assess the costs of climate change by evaluating the damage functions related to temperature increases and their effects on economic output. Nordhaus's work, however, has proven controversial. Debates on his assumptions (e.g. climate change will be a gradual and linear process); ethical concerns, particularly on discounting potential disproportionate impacts on vulnerable populations; and even his conclusions on 'economically optimal' levels of warming, have fuelled a generation of research (Hayden, 2021; Masini, 2021).

A pivotal moment in the literature was the publication of the Stern Review, which found that the costs of inaction on climate change would be significantly higher than the costs of mitigation (Stern, 2007; Stern et al., 1994). In part due to these findings, global emphases shifted to the potential mechanisms for enforcing transitions in economic processes to accelerate mitigating the expected costs of climate change on global GDP (IPCC, 2023, 2014, 2007, 2003, 1995, 1992). As a result, there was increased interest in methods to estimate sectoral carbon emissions, with the underlying assumption that sectoral interventions can have scalar effects on mitigatory impacts at the country (GDP) level, leading to positive effects at the global scale. Prevalent methods involve estimating sectoral energy use by calculating emissions as a share of the energy-mix of energy production at the aggregate level, in other words, an energy use accounting framework (IEA, 2021). South Africa has also been producing a report on their carbon emissions using a similar approach (Department of Environmental Affairs, 2014). However, these methodologies provide an incomplete picture of sectoral level carbon emissions. For example, energy use is only one component of carbon emissions that can emanate from production and consumption processes in a sector. More recent methodologies have sought to determine the true social costs of emissions within consumption and production processes of an economy by combining modern data generation and processing tools with older techniques like Input-Output (IO) Analysis and computable general equilibrium models (Miller & Blair, 2022).

This paper uses EXIOBASE 3 Tables which are a variant of established Input-Output Analysis models: the Multi-Region Input-Output (MRIO) Materials Flows analysis (Merciai & Schmidt, 2018; Stadler et al., 2018). In brief, Input-Output (IO) tables are a quantitative economic method to represent the interdependencies between different sectors of a national economy or different regional economies. They are used to analyse the flow of goods and services within an economy, showing how the output of one industry is an input to another industry, and using the Leontief Production Function approach, they allow for the estimation of aggregate demand and aggregate supply of a region (Leontief, 1970; Miller & Blair, 2022). Recent data collection innovations have allowed for incorporating environmental factors as inputs for production and consumption processes within the IO tables, thereby as a corollary to the estimates of aggregate demand and aggregate supply, one is also able to estimate the emissions generated by each sector considered in the IO tables being used (UNEP IRP et al., 2024). The top-down approach utilises this sectoral emissions data.⁶

3.1. Industry pollution and emission intensity estimates

South Africa's carbon footprint reveals a strong disconnect between the primary sources of greenhouse gas emissions and the principal sectors of employment. This dichotomy is illuminated by two key metrics: pollution intensity and emissions intensity. Together, these metrics show that a small, low-employment segment of the economy is responsible for a vast majority of carbon pollution, while sectors employing millions have a

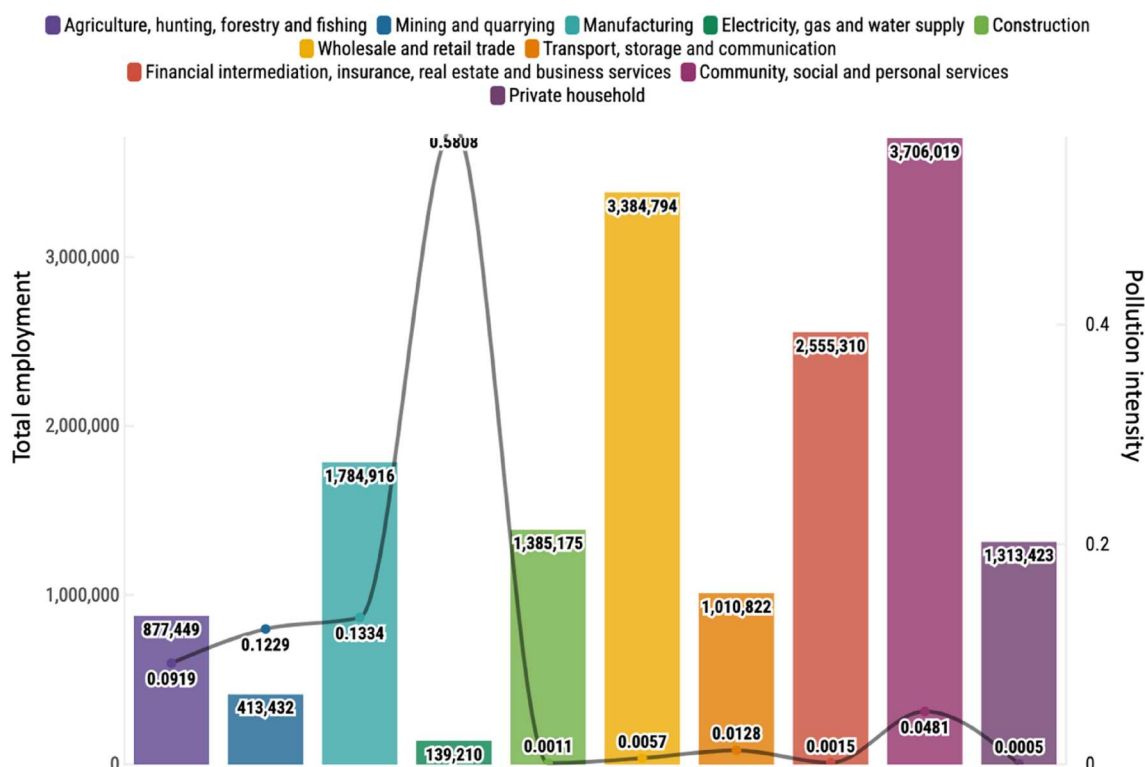


Figure 1. Pollution intensity and employment by industrial sector, 2019. Source: Own calculations using data from EXIOBASE 3 and Labour Dynamics Survey 2019 (Statistics South Africa, 2019).

negligible direct footprint. Understanding this structural imbalance is the foundational step in formulating equitable strategies for a ‘just economic transition’.

For the year 2019, [Figure 1](#) shows the pollution intensity of industrial sectors (i.e. share of carbon emissions contributed by each industrial sector) based on the Standard Classification of Industry (SIC) 5th edition, alongside total employment in those sectors. The bars represent employment in each industrial sector and the line represents the share of CO₂ contributed by each industrial sector.

The ‘Electricity, gas and water supply’ sector, heavily reliant on coal-fired power plants, exhibits a pollution intensity of 0.58. In other words, it accounts for 58% of the nation’s total carbon dioxide (CO₂) emissions. This observation aligns with studies such as [Hughes et al. \(2021\)](#), which inform us that 85% of electricity in South Africa was produced through coal power plants in 2021. At the same time, this sector is one of the smallest employers, with only 139 210 workers.⁷ In contrast, ‘Community, social and personal services’ (3.7 million workers), ‘Wholesale and retail trade’ (3.4 million), and ‘Financial services’ (2.6 million) collectively employ over 30% of the nation’s workforce, yet contribute a mere 6% to total CO₂ emissions. This decoupling of employment from emissions highlights a key policy reality: while a substantial portion of the economy can be supported without directly exacerbating the emissions problem, these sectors remain highly vulnerable to the indirect effects of a poorly managed energy transition, such as volatile electricity pricing and unreliable supply.

The per-capita perspective offered by emissions intensity further sharpens this focus. As detailed in [Figure 2](#), a worker in the electricity sector is associated with an emissions intensity of 1949.7 tonnes of CO₂ per worker, a figure that dwarfs the national average of 56 tonnes per worker, and quantifies the extreme, concentrated labour risk in this sector.

This carbon liability is not isolated, but is embedded within a systemic national carbon value chain. The ‘Mining and quarrying’ sector’s significant footprint (138.9 CO₂ tonnes per worker and 12% of national emissions) is largely indirect, stemming from its role as an upstream supplier of coal. Likewise, the ‘Manufacturing’ sector’s high carbon contribution is a downstream consequence of its position as one of the largest consumers of this coal-powered

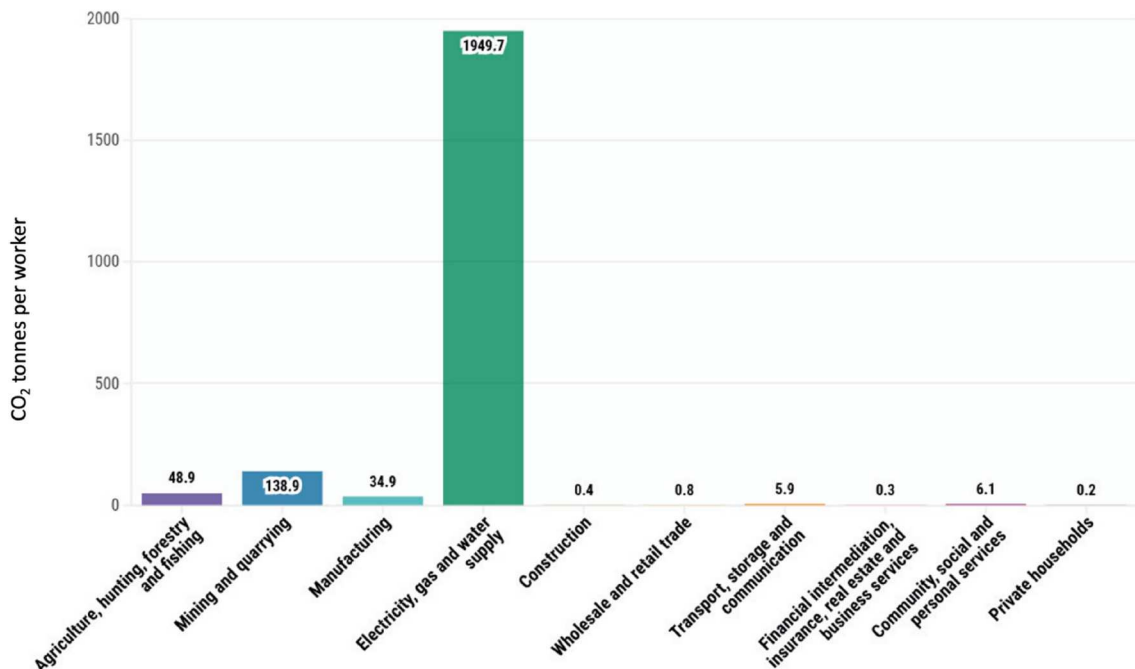


Figure 2. Emission intensity by industry, 2019. Source: Own calculations using data from EXIOBASE 3 and Labour Dynamics Survey 2019 (Statistics South Africa, 2019).

electricity. This systemic view reveals that decarbonising the central node – the electricity grid – is probably the most impactful intervention for reducing embedded carbon across the entire industrial ecosystem.

These analytical findings provide a clear, evidence-based roadmap for policy aligned with South Africa's Nationally Determined Contributions (NDCs), which explicitly imply a structural change of the economy. A central tenet of this change is the just transition, which mandates identifying and supporting the most vulnerable workers. The intensity metrics achieve this by identifying both sectoral risk and per-capita exposure (Presidential Climate Commission, 2024a; The Presidency, Republic of South Africa, 2023b).

A final point on these indicators: for both pollution and emissions intensity, one should note that they are time-sensitive in nature. As they are extracted from global MRIO tables, our time intervals and horizons are constrained by the data source. In its current iteration, the data source used here, i.e. EXIOBASE 3, can allow for annual estimations of sectoral carbon emissions from 1995 till 2022. They are also locally contextual measures, as they present a relative picture of how different sectors in a selected economy, and the labour force in each of these sectors, are performing vis-à-vis carbon emissions. This makes them strongly linked with national economic development strategies. For example, with electricity production witnessing a strong transition away from coal-based power generation in South Africa, it is conceivable that the pollution intensity of the electricity, gas, and water supply sector will witness a strong decline in more recent time periods.

The top-down approach allows us to build a profile of workers that will likely be affected by the green transition, based on their industry. Similarly, the bottom-up approach can do this based on their occupation. This next section details how the environmental profiles of both industry and occupation can be brought together in the Framework to build a more comprehensive picture of potential vulnerability.

4. The green transition framework

The Green Transition Framework combines the bottom-up and top-down approaches in the form of a matrix, bringing together occupation and industry level information to help answer labour market questions in the context of the green transition.

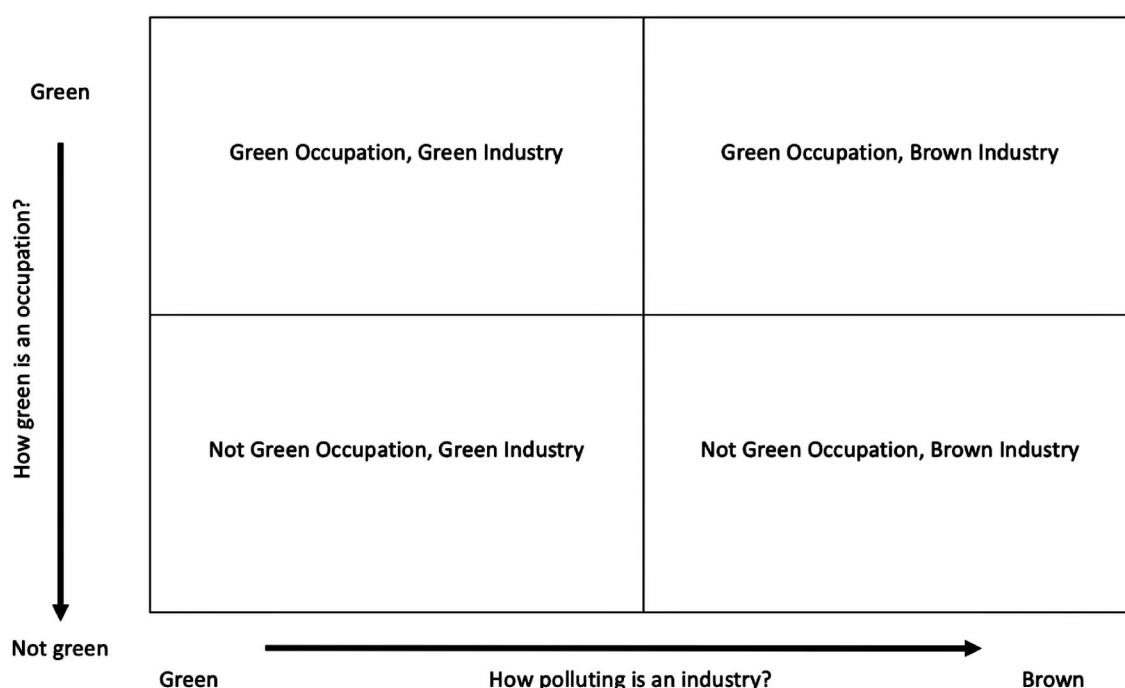


Figure 3. The Green Transition Framework: a framework for understanding the effects of the green transition on the labour market.

The green transition has, and will, bring about many changes to the labour market. The occupation in which workers are employed, and the industry where they work, are both crucial aspects of answering labour market questions about the green transition. Considering only occupation, or only industry, tells one side of the story. Both what a worker does, and the industry in which they do it, matter when looking at labour market transitions. The Framework integrates these two to provide a more holistic approach for analysing and contextualising the potential employment effects of the green transition.

Figure 3 depicts the Framework as a generalised matrix consisting of two dimensions: the vertical axis represents green occupations, and the horizontal axis reflects the polluting nature of the industry, from green to brown. Users can choose from a range of green or brown job definitions and measures for the axes. Examples include the O*NET green occupation classifications, green task intensity indices, pollution intensity measures or brown occupation measures, as per Vona et al. (2018). In addition, they can select the dataset used, such as locally available employment data, and determine how this data is represented, including the unit of analysis and the measurement metric. In the present study's illustrative applications of the framework, workers constitute the unit of analysis. By contrast, Davidson et al. (2025) demonstrate the flexibility of the framework by employing geographic areas as their unit of analysis, thereby generating estimates of green occupation and brown sector employment at the regional level. In addition, Davidson et al. (2025) make use of publicly available anonymised tax data, instead of the labour market data on which this paper relies. This makes it a versatile tool suitable for application across diverse contexts to address key research questions on the labour market and the green transition.

4.1. Example analysis using the green transition framework

This section details an example of how the Green Transition Framework can be implemented, building off the above applications of the bottom-up and top-down approaches.⁸ Specifically, the following question is considered: How much of the workforce in heavily polluting industries is employed in 'green transition occupations'? This research question seeks to simultaneously identify those workers at risk of job loss due to the

polluting nature of the industry in which they work (pollution intensity), and those who have potentially transferable skillsets allowing them to move more easily to newer green economy jobs ('green transition occupations'). Figure 4 demonstrates how the Green Transition Framework can be used to answer this question, and each stage of the process is detailed below.

The nature of the question being addressed drives the decisions regarding the measures for the axes, and the unit of analysis of the Framework. 'Green transition occupations' are utilised for the bottom-up approach, on the vertical axis, and pollution intensity for the top-down approach, on the horizontal axis. 'Green transition occupations' indicate workers who are able to perform work that may be relevant to the green economy. Pollution intensity identifies heavily polluting industries, where workers are more at risk of job losses, based on each industry's contribution to total CO₂ emissions. In this example, the concentration of green transition workers within each industry is plotted by expressing employment in 'green transition occupations', in each one-digit industry, as a percentage of total employment in the industry.

The most polluting industries are found to have higher concentrations of 'green transition occupation' workers, whereas those contributing less to emissions have lower concentrations. For example, within the high-risk electricity sector, 31% of the workforce is employed in 'green transition occupations'. The substantial representation of green transition workers within these industries can be attributed to the overlap between the technical competencies they require and those integral to advancing the green transition. For instance, transforming South Africa's electricity generation system represents a critical component of the transition. The specialised expertise concentrated in this sector will therefore be essential to enabling and sustaining such structural change. This suggests that there are high proportions of workers in these industries, where job losses are expected due to the green transition, who can do tasks which could support the green economy. Furthermore, this indicates that not all workers in these vulnerable industries necessarily face the same

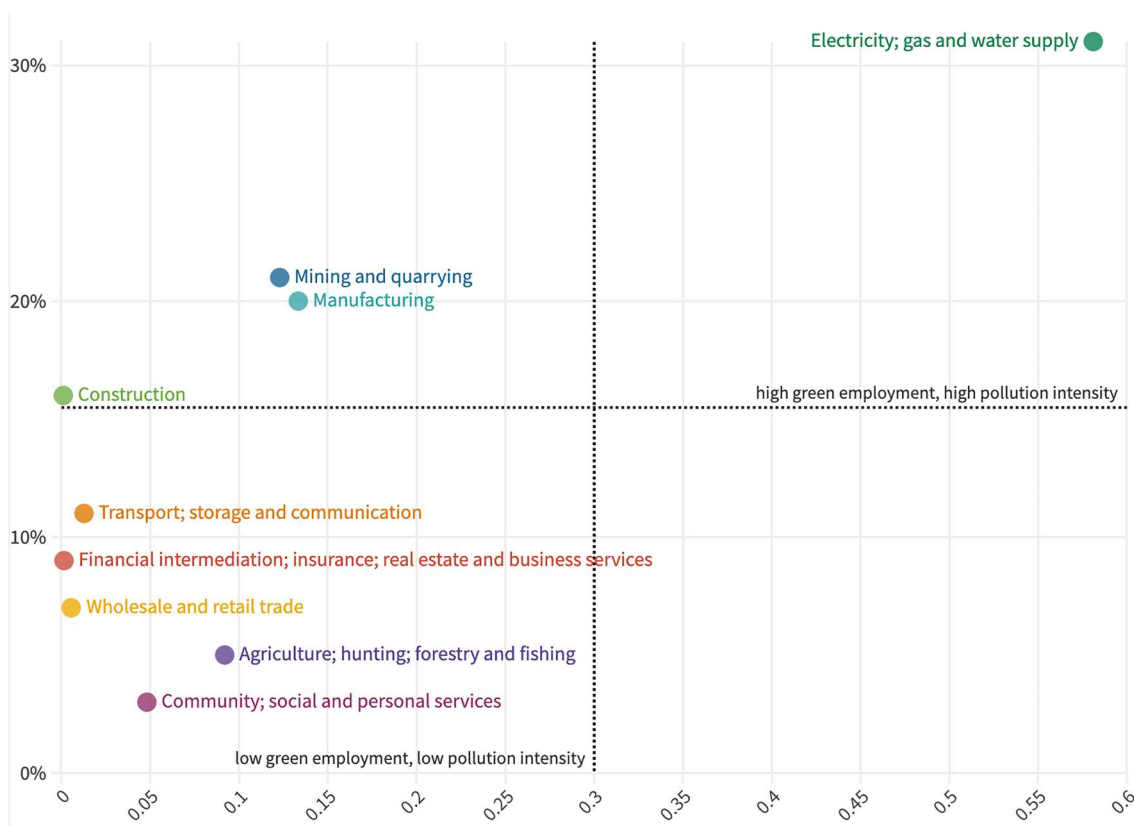


Figure 4. Proportion of workers in 'green transition occupations' and pollution intensity, by industry, 2019. Source: Own calculations using data from EXIOBASE 3 and Labour Dynamics Survey 2019 (Statistics South Africa, 2019).

degree of vulnerability to the green transition. Observations such as these challenge a simplistic narrative of sectoral decline, instead demanding a nuanced, occupation-level policy focused on reskilling and internal restructuring rather than just managing displacement.

Moreover, the framework serves as a tool for examining the risks faced by different groups of workers. Figures C1 and C2 in Appendix C depict the Green Transition Frameworks for male and female workers, respectively. A useful measure to compare these two figures is the Euclidean distance between the origin and reference point of each framework. This measure reveals a significant gap: the distance equals 16 for the men and only 12.5 for the women. As the industrial pollution intensity on the horizontal axis remains constant for both figures, the source of the divergence lies in the relative proportions of workers employed in green transition occupations. Across all industries, men are consistently more likely to occupy such positions. The largest gender disparity is observed in the Manufacturing sector, where 27% of male workers are employed in green transition occupations compared with only 8% of female workers. These findings suggest that men may be better positioned to transition to work in the green economy, owing to their greater representation in green transition occupations. This has implications for implementing existing policy, such as, *A Framework for a Just Transition in South Africa, the Just Energy Transition Investment Plan and the Just Energy Transition Implementation Plan*, all of which highlight the potential for the transition to worsen existing gender inequalities (Presidential Climate Commission, 2024; The Presidency, Republic of South Africa, 2023b, 2023a).

5. Discussion and conclusion

In South Africa, questions surrounding the effects of the green transition are centred on electricity and energy generation processes. The implications of transitioning towards a green economy are strongly linked to the impacts both upstream and downstream of the energy generation supply chain. Both the carbon footprints of industries, as well as workers with the necessary skills as determined by their occupation, are directly linked to the high carbon footprint of electricity generation. Combining these measures in the Green Transition Framework gets us closer to identifying workers who may be at risk or, on the other hand, better placed to withstand the risks associated with the green transition. The framework seeks to synthesise the strengths of both these rich perspectives to provide a more comprehensive and versatile analytical tool for examining the dynamics of the green transition.⁹

The methodology draws on and combines bottom-up and top-down approaches to identify both the greenness of the occupation of a worker, and the industry in which they are employed. The lists of green occupations developed by O*NET are used to identify green employment in the bottom-up approach, and pollution and emissions intensity measures form the basis of the top-down approach. Combining these methods in the Green Transition Framework allows the derivation of an individual-level worker profile to be developed. The flexibility of the Framework extends its application beyond the individual-level worker, where for example communities or municipalities could be plotted as the unit of analysis, with adjusted measurements on the axes, depending on the question at hand. The paper presents two examples demonstrating how the framework can be applied. These examples offer preliminary evidence that workers in polluting industries may possess skills relevant to the green economy, potentially reducing the risk of long term joblessness, and that men may be better positioned to transition into work in the green economy. Such findings suggest that workers face varying levels of vulnerability, highlighting the need for tailored policy interventions.

A further appealing feature of the Framework, which extends its usefulness beyond the South African setting, is that it can work across various definitional systems. However, context plays a vital role in understanding the effects of the green transition on the labour market, and each economy will have specific factors which influence the effects of the green transition on its labour market.

Considering the imperative for the transition to be just and fair, this approach has the potential to assist in the development of targeted policy and intervention strategies, as well as to track the impact that the transition is having on the labour market over time.

To effectively govern such transitions, policymakers need dynamic indicators that move beyond tracking aggregate emissions, which fail to capture aspects relating to achieving a just transition such as the distribution of skills in the labour market and who possesses them. For example, for a just transition, one could track the

ratio of employment growth to emissions growth, within a sector. A positive outcome, where employment grows faster than emissions, would signal a successful decoupling of economic progress from environmental harm. The Green Transition Framework could be used to track such dynamic metrics over time to provide a comprehensive picture of the progress of the transition. In addition, ongoing comparisons of the results to national decarbonisation and just transition targets would add additional context to better track progress. By adopting and tracking such metrics, policymakers can ensure the twin goals of decarbonisation and inclusive development are pursued in parallel, guiding South Africa toward an environmentally sustainable and socially equitable future.

Notes

1. Examples of studies using the task intensity approach include Bluedorn et al. (2022); Elliott et al. (2021); Granata and Posadas (2024); (2019); Mosomi and Cunningham (2024); OECD (2023); Cerimelo et al. (2024); Tyros et al. (2023); García-Suaza et al. (2025). For a more detailed discussion of the green occupation literature, see Davidson et al. (2024).
2. Department of Public Service and Administration released *The Public Service Occupational Classification System: Occupational Dictionary* in 2024 (Department of Public Service and Administration, 2024). The dictionary seeks to improve how occupations in the public sector are categorised and defined. The Centre for Researching Education and Labour (2022) gives a comprehensive overview of the two systems and their rationale. Future refinements to our methodology will include any relevant revisions from this recent classification system update.
3. This general methodology for identifying and quantifying employment in 'green transition occupations' in the South African context is flexible and can be applied to several different green occupation definitions other than O*NET. A more detailed explanation of the methodology can be found in Davidson et al. (2024).
4. See Appendix A for a more detailed explanation of this step of the methodology.
5. A crosswalk obtained directly from the Department of Higher Education and Training was used to match occupations across these two classification systems. This crosswalk is similar to that developed by International Labour Organisation's to match ISCO-08 and ISCO-88 occupations.
6. For further details on the process used to calculate these industrial carbon emissions, see Appendix B.
7. As an order of magnitude, Makgetla et al. (2019) estimate that in the coal value chain (mostly comprised of coal mining, power generation and petrochemical production) the number of workers at risk was of around 120 000.
8. Davidson et al. (2024) provides further preliminary empirical analysis of the Green Transition Framework using South Africa labour market data.
9. The focus of this paper is to present the conceptual foundations of the framework, however an example of an application of the framework to South African labour market data can be found in Davidson et al. (2025).

Acknowledgements

We would like to acknowledge the input of the Associate Professor. Justin Visagie (Human Sciences Research Council and University of the Free State) and Andrew Nell (Freelance Consultant and Data Scientist).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Agence Française de Développement under Grant AFD/ISR/ECO/882-2023.

Data availability statement

The data that support the findings of this study are openly available in Datafirst at <https://doi.org/10.25828/KJGZ-YY35>

References

Amis, A. M., Montmasson-Clair, G., Lugogo, S., & Benson, E. (2018). *The green economy barometer 2018. The African centre for a green economy*. Trade and Industrial Policy Strategies.

- Becerra, O., Piñeros-Ruiz, J., & David, A. (2024). Quantifying Green Job Potential in Colombia: A Task-Based Approach. *AFD Research Papers*, pp. 2–28.
- Becker, R. A., & Shadbegian, R. J. (2009). Environmental products manufacturing: A look inside the green industry. *The B.E. Journal of Economic Analysis & Policy*, 9(1), 1–25. <https://doi.org/10.2202/1935-1682.2117>
- Bhorat, H., Kupeta, T., Martin, L., & Steenkamp, F. (2024). *Just transition and the labour market in South Africa: Measuring individual and household coal economy dependence* (202402). Cape Town: Development Policy Research Unit.
- Bluedorn, J., Hansen, N.-J., Noureldin, D., Shibata, I., & Tavares, M. M. (2022). A greener labor market: Employment, policies, and economic transformation. In J. Procopio (Ed.), *World economic outlook, April 2022: War sets back the global recovery, world economic outlook*. International Monetary Fund. <https://doi.org/10.5089/9781616359423.081>
- Bowen, A., & Hancke, B. (2019). *The social dimensions of 'greening the economy'*. European Commission.
- Bowen, A., Kuralbayeva, K., & Tipoe, E. L. (2018). Characterising green employment: The impacts of 'greening' on workforce composition. *Energy Economics*, 72, 263–275. <https://doi.org/10.1016/j.eneco.2018.03.015>
- Burton, J., Caetano, T., & McCall, B. (2018). Coal transitions in South Africa. Understanding the implications of a 20C-compatible coal phase-out plan for South Africa. *IDDRI Clim. Strateg.*
- Cerimelo, M., Vega, P. d. l., Porto, N., & Vazquez, F. (2024). Beyond traditional wage premium. An analysis of wage greenium in Latin America. *CEDLAS Working Papers*, CEDLAS, Working Papers.
- Davidson, K., David, A., De Lannoy, A., Grotte, J., Jana, A., Leibbrandt, M., Nell, A., & Visagie, J. (2025). The impact of the green transition on jobs in South Africa (No. 318). Southern Africa Labour and Development Research Unit, Cape Town.
- Davidson, K., Lannoy, A. D., Grotte, J., Jana, A., David, A., & Leibbrandt, M. (2024). An analytical framework to assess green transition jobs in South Africa (No. 309). Southern Africa Labour and Development Research Unit.
- De La Vega, P., Porto, N., & Cerimelo, M. (2024). Going green: Estimating the potential of green jobs in Argentina. *Journal for Labour Market Research*, 58(1), 1. <https://doi.org/10.1186/s12651-023-00359-2>
- Department of Environmental Affairs. (2014). *GHG inventory for South Africa*. Department of Environmental Affairs, Republic of South Africa.
- Department of Forestry, Fisheries and the Environment. (2024). Sectoral emission targets 2025 to 2030. Department of Forestry, Fisheries and the Environment.
- Dierdorff, E. C., Norton, J. J., Drewes, D. W., Rivkin, D., & Lewis, P. (2009). Greening of the world of work: Implications for O*NET®-SOC and new and emerging occupations.
- Dierdorff, E. C., Norton, J. J., Gregory, C. M., Rivkin, D., & Lewis, P. (2011). Greening of the world of work: Revisiting occupational consequences.
- Elliott, R. J. R., Kuai, W., Maddison, D., & Ozgen, C. (2021). Eco-innovation and employment: A task-based analysis. *IZA Discussion Papers*, 14028, 2–69.
- Elliott, R. J. R., & Lindley, J. K. (2017). Environmental jobs and growth in the United States. *Ecological Economics*, 132, 232–244. <https://doi.org/10.1016/j.ecolecon.2016.09.030>
- European Environment Agency. (2024). Extreme weather: Floods, droughts and heatwaves [WWW Document]. Retrieved February 26, 2025, from <https://www.eea.europa.eu/en/topics/in-depth/extreme-weather-floods-droughts-and-heatwaves>
- Eurostat. (2024). Environmental economy – Statistics on employment and growth, 2020–21. Eurostat.
- García-Suaza, A., Caiza-Guamán, P., Sarango-Iturralde, A., Romero-Torres, B., & Buitrago, C. (2025). Green jobs and the green transition in Latin America and the Caribbean: A labor market analysis using job vacancy data (Working paper no. 1625). GLO discussion paper.
- Granata, J., & Posadas, J. (2024). Why look at tasks when designing skills policy for the green transition? A methodological note on how to identify green occupations and the skills they require. *World Bank Policy Research Working Papers*, 1, 10753. <https://doi.org/10.1596/1813-9450-10753>
- Hayden, F. G. (2021). Critique of concepts about systems and time in William Nordhaus's research about climate change. *Journal of Economic Issues*, 55(2), 447–453. <https://doi.org/10.1080/00213624.2021.1909343>
- Hughes, A., Merven, B., McCall, B., Caetano, T., Hartley, F., & Ahjum, F. (2021). *Evolution, assumptions and architecture of the South African energy systems model SATIM*. ESRG Working Paper.
- IEA. (2021). *Key world energy statistics 2021*. International Energy Agency.
- International Renewable Energy Agency, International Labour Organisation. (2023). *Renewable energy and jobs: Annual review, 2023*.
- IPCC. (1992). *Climate change: The 1990 and 1992 IPCC assessments*. Intergovernmental Panel on Climate Change (IPCC), United Nations Environment Programme.
- IPCC. (1995). *Climate change 1995: IPCC second assessment*. Intergovernmental Panel on Climate Change (IPCC), United Nations Environment Programme.
- IPCC. (2003). *Climate change 2001: Synthesis report*. Intergovernmental Panel on Climate Change (IPCC), United Nations Environment Programme.
- IPCC. (2007). *Climate change 2007: Synthesis report*. Intergovernmental Panel on Climate Change (IPCC), United Nations Environment Programme.
- IPCC. (2014). *Climate change 2014: Synthesis report*. Intergovernmental Panel on Climate Change (IPCC), United Nations Environment Programme.

- IPCC. (2023). *Climate change 2023: Synthesis report*. Intergovernmental Panel on Climate Change (IPCC), United Nations Environment Programme. <https://doi.org/10.59327/IPCC/AR6-9789291691647>
- Leontief, W. (1970). Environmental repercussions and the economic structure: An input-output approach. *The Review of Economics and Statistics*, 52(3), 262–271. <https://doi.org/10.2307/1926294>
- Makgetla, N., Maseko, N., Montmasson-Clair, G., & Patel, M. (2019). *National employment vulnerability assessment: Analysis of potential climate- change related impacts and vulnerable groups*. Trade and Industrial Policy Strategies.
- Masini, F. (2021). William nordhaus: A disputable nobel [prize]? externalities, climate change, and governmental action. *The European Journal of the History of Economic Thought*, 28(6), 985–1004. <https://doi.org/10.1080/09672567.2021.1963798>
- Merciai, S., & Schmidt, J. (2018). Methodology for the construction of global multi-regional hybrid supply and Use tables for the EXIOBASE v3 database. *Journal of Industrial Ecology*, 22(3), 516–531. <https://doi.org/10.1111/jiec.12713>
- Miller, R. E., & Blair, P. D. (2022). *Input-output analysis: Foundations and extensions, third edition*. Ed. Cambridge University Press. <https://doi.org/10.1017/9781108676212>
- Mosomi, J., & Cunningham, W. (2024). *Profiling green jobs and workers in South Africa: An occupational tasks approach*. Working Paper.
- Nordhaus, W. (1977). Economic growth and climate: The carbon dioxide problem. *Am. Econ. Rev.*, 67, 341–346.
- Nordhaus, W. (2019). Climate change: The ultimate challenge for economics. *American Economic Review*, 109(6), 1991–2014. <https://doi.org/10.1257/aer.109.6.1991>
- Nordhaus, W. D. (1991). To slow or Not to slow: The economics of The greenhouse effect. *The Economic Journal*, 101(407), 920–937. <https://doi.org/10.2307/2233864>
- OECD. (2023). Job creation and local economic development 2023: Bridging the great green divide, job creation and local economic development. OECD. <https://doi.org/10.1787/21db61c1-en>
- O*NET. (2025). 11-1011.03 - Chief sustainability officers [WWW Document]. Retrieved June 27, 2025, from <https://www.onetonline.org/link/summary/11-1011.03>
- Presidential Climate Commission. (2024). *A framework for a just transition in South Africa*. The Presidency, Republic of South Africa.
- Stadler, K., Wood, R., Bulavskaya, T., Södersten, C.-J., Simas, M., Schmidt, S., Usubiaga, A., Acosta-Fernández, J., Kuenen, J., Bruckner, M., Giljum, S., Lutter, S., Merciai, S., Schmidt, J. H., Theurl, M. C., Plutzar, C., Kastner, T., Eisenmenger, N., Erb, K.-H., ... Tukker, A. (2018). EXIOBASE 3: Developing a time series of detailed environmentally extended multi-regional input-output tables. *Journal of Industrial Ecology*, 22(3), 502–515. <https://doi.org/10.1111/jiec.12715>
- Statistics South Africa. (2019). *Labour market dynamics in South Africa 2019 [dataset]. version 1.1*. Statistics South Africa. Cape Town: DataFirst [distributor], 2021. <https://doi.org/10.25828/KJGZ-YY35>
- Stern, D. I., Common, M. S., & Barbier, E. B. (Eds.), (1994). Economic growth and environmental degradation: A critique of the environmental kuznets curve. 9409. <https://doi.org/10.22004/ag.econ.263933>
- Stern, N. H., Great Britain (Eds.)(2007). *The economics of climate change: The stern review*. Cambridge University Press.
- The Presidency, Republic of South Africa. (2023a). *South Africa's just energy transition investment plan for the initial period 2023-2027*. The Presidency, Republic of South Africa.
- The Presidency, Republic of South Africa. (2023b). *Just energy transition implementation plan 2023-2027*. The Presidency, Republic of South Africa.
- Thomas, G. (2022). *Low carbon and renewable energy economy*. Office for National Statistics.
- Tyros, S., Andrews, D., & de Serres, A. (2023). Doing green things: Skills, reallocation and the green transition (OECD Working Paper No. 1763). Organisation for Economic Co-operation and Development.
- UNEP IRP, Australian National Science Agency, Commonwealth Scientific and Industrial Research Organisation. (2024). Technical annex for global material flows database - Version 4 (Technical Annex). Commonwealth Scientific and Industrial Research Organisation, Canberra.
- US Environmental Protection Agency. (2024). Climate change indicators: Weather and climate | US EPA [WWW Document]. Retrieved February 26, 2025, from <https://www.epa.gov/climate-indicators/weather-climate>
- Valero, A., Li, J., Muller, S., Riom, C., Nguyen-Tien, V., & Draca, M. (2021). Are “green” jobs good jobs? How lessons from the experience to-date can inform labour market transitions of the future. Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science, London.
- Vandeplass, A., Vanyolos, I., Vigani, M., & Vogel, L. Directorate-General for Economic and Financial Affairs, (2022). The possible implications of the green transition for the EU labour market - European Commission (No. Discussion Paper 176). Office of the European Union.
- Vona, F., Marin, G., & Consoli, D. (2019). Measures, drivers and effects of green employment: Evidence from US local labor markets, 2006–2014. *Journal of Economic Geography*, 19(5), 1021–1048. <https://doi.org/10.1093/jeg/lby038>
- World Resources Institute. (2021). South Africa: Strong foundations for a just transition.