WESTERN CAPE FREIGHT DEMAND MODEL

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2022 Model | Report | December 2023

Amidst the ongoing logistics crisis in South Africa, successful national and regional macrologistics interventions have proven to be critically dependent on a data-driven approach. The evidence-based macrologistics planning for infrastructure investment and policy direction necessitates an activity-based data and costing framework, mirroring the precision required for logistics on a business level. Just as in business logistics, where trade-offs between strategic alternatives and investment choices demand a comprehensive analysis of logistic activities, the same principle holds for national and regional logistics planning. In South Africa's logistics crisis, exacerbated by inefficiencies within Transnet and the railways incapacity to serve the industry, a demand-based freight flow model has proven to be a crucial and empowering tool to determine and evaluate potential solutions. In the current context, understanding the flow of goods on a national and provincial scale is paramount, and this need can be effectively met through a demand-based flow model. The South African National Freight Demand Model™ captures freight flows between 372 districts for 83 commodities for export, import and domestic freight, over a 30-year forecast horizon.

This approach mirrors successful practices seen in the developing world, such as India[1], Uzbekistan[2], and Mongolia[3], where demand-based flow models have led to the identification of infrastructure gaps, informed transport policies, and facilitated economic growth.

A freight flow model not only provides insight into the current volumes of freight on each transport mode throughout the region, but also assigns costs to these flows. This is current demand which is related to the current GDP of the region in question, also often called "GDP in motion". With forecasts, future demand for each of these flows can be determined, and thereby enable a range of analytical opportunities for the decision-maker. Policy interventions and industrialisation strategies can be evaluated, including the effects on infrastructure, cost-benefit analyses of modal choices, and assessments of congestion measures and law enforcement.

The South African transport and logistics industry is currently under extreme pressure and faces a multifaceted crisis that has been exacerbated by a confluence of factors. Firstly, the global impact of COVID-19 pandemic has caused havoc on supply chains, causing disruptions, delays and logistical challenges worldwide. South Africa being a crucial player in the global trade network, has felt the repercussions of these disruptions. Moreover, the crisis has been intensified by the persistent inefficiencies within Transnet and the railways' inability to service the industry and contribute to the South African economy". President Cyril Ramaphosa recognised the gravity of the situation and the imperative for immediate action, and has taken various actions to address the logistics crisis in the country. These actions include interventions in Transnet, infrastructure investment, policy reform and collaboration between the government and industry stakeholders (State of the Nation address, 2023). While these actions have been taken, addressing a logistics crisis of this magnitude is a complex and ongoing process. It may take time to fully resolve all the challenges faced by the sector.

National and Provincial government need to develop comprehensive strategies that can mitigate the effects of the crisis and lay the foundation for a more resilient and efficient logistics sector. In this context, the Western Cape Provincial Government has emerged as a pioneer in addressing the crisis head-on. The seventh iteration of the WC FDM™ plays a pivotal role in shedding light on the intricacies of freight movement within the Western Cape. By analyzing data from 2022, this Western Cape Freight Demand Model (WC FDM™) report offers invaluable insights into the sources of data, the rigorous methodology employed, and the results generated. These insights serve as a foundation for strategic decision-making, ensuring that policies and interventions are well-informed and targeted for maximum impact. This commitment to transparency and data-driven decision-making underscores the Western Cape Provincial Government's dedication to addressing the logistics crisis and fostering sustainable growth in the region's transport and logistics industry.

[1] Simpson, Z.P., Havenga, J.H., Witthöft, I.E. & Aritua, B. 2021. Spatially and commodity-level disaggregated freight demand modeling in emerging economies: applications for South Africa and India, in I. Kourounioti, L. Tavasszy & H. Friedrich (eds.). *Freight Transport Modeling in Emerging Countries*. Amsterdam: WCTRS Elsevier. 151-183, https://doi.org/10.1016/C2019-0-02543-5

[2] The World Bank. 2020. *Uzbekistan - Building Blocks for Integrated Transport and Logistics Development: Policy Paper*. [Washington, D.C.]: World Bank Group [Online]. Available: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/620601593145818606/uzbekistan-building-blocks-for-integrated-transport-and-logistics-development-policy-paper [2022, March 28]

[3] World Bank. 2020. *Mongolia InfraSAP: Infrastructure for Connectivity and Economic Diversification*. [Ulaanbaatar]: World Bank Group [Online]. Available: http://hdl.handle.net/10986/34779 [2022, March 28].

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Executive summary

Amidst the ongoing logistics crisis in South Africa, successful national and regional macrologistics interventions have proven to be critically dependent on a data-driven approach. National and Provincial government need to develop comprehensive strategies that can mitigate the effects of the crisis and lay the foundation for a more resilient and efficient logistics sector. In this context, the Western Cape Provincial Government has emerged as a pioneer in addressing the crisis head-on. The seventh iteration of the WC FDM™ plays a pivotal role in shedding light on the intricacies of freight movement within the Western Cape. By analyzing data from 2022, this Western Cape Freight Demand Model (WC FDM™) report offers invaluable insights into the sources of data, the rigorous methodology employed, and the results generated. These insights serve as a foundation for strategic decision-making, ensuring that policies and interventions are well-informed and targeted for maximum impact. This commitment to transparency and data-driven decision-making underscores the Western Cape Provincial Government's dedication to addressing the logistics crisis and fostering sustainable growth in the region's transport and logistics industry.

The WC FDM™ supports strategic decision-making in the implementation of the Western Cape Freight Strategy. This report outlines the methodology and data sources of the model, and summarises key characteristics associated with freight flows to, from, and within the Western Cape, as well as a potential scenario for modal shift and terminal networks in the province.

Methodology

The national and provincial freight demand models are comprised of econometric and flow modelling. Econometric modelling identifies and analyses causes and effects, and correlates relationships between total freight transport demand and its drivers. Flow modelling uses the supply and demand values of the econometric model to represent freight movement between supply and demand areas for all commodities and modes. This report also provides more detail regarding waste and forecasted waste as well as detailing the challenges regarding air freight data.

The models are based on Logistics Service Provider cost and tariff data (interview-based), Transnet Freight Rail data, Transnet National Ports Authority data, Western Cape- specific data (agriculture, crops, and mining), Western Cape- specific waste data, international air freight data for Cape Town International Airport, and publicly available industry and business data.

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Provincial modal split

The total road and rail freight with an origin or destination in the Western Cape in 2022 amounted to 142.3 million tonnes, showing a negligible increase from the previous year. The modal split remained unchanged, with road accounting for 60% and rail accounting for 39% of total freight. For GFB[1] freight, road dominated with a 98% market share, while rail had a 2% market share. The mining sector, driven by export iron ore, was the dominant contributor to rail freight volumes.

Agriculture freight by rail grew by 15%, while mining and manufacturing contracted by 21% and 22% respectively. Rail lost 11% market share of GFB volumes in 2022. Opportunities exist for rail transport of long-distance GFB freight, particularly in the agricultural and fruit sectors. The closure of Saldanha Steel and the lack of consolidation facilities and service levels have impacted rail volumes.

Provincial trade

The Western Cape GFB freight (66.4 million tonnes) is split between intra-Western Cape freight (22.3 million tonnes), freight transported to other provinces (24.3 million tonnes) and freight received from other provinces (19.8 million tonnes). Waste is an intra-provincial flow only and amounts to 2.5 million tonnes (11.5% of intra-provincial flow). Almost half (48%) of intra-Western Cape freight and 75% of freight to other provinces, amounting to 28.9 million tonnes, consists of manufacturing commodities. Processed foods represent the largest manufactured commodity group (30%), followed by beverages (11%).

KwaZulu-Natal is the Western Cape's main GFB trading partner, followed closely by Gauteng. If it was not for port-related trade, Gauteng would have been the Western Cape's biggest trading partner, because 22.6% of trade with KZN is related to the Port of Durban.

Corridors

Corridor GFB freight is dominated by road, with a 99.1% market share on the N1 corridor; 99.7% market share on the N2 corridor and 86.6% market share on the N7 corridor . The average travel distance of road freight on the N1, N2, N7, Metropolitan and Core Western Cape corridor is 1 395 km, 645 km, 388 km, 27km and 81km respectively. More than half of the freight moving on the N1 is related to food commodities. Modal shift opportunities exist for long-distance road freight in the Western Cape.

[1] GFB is defined as the competitive market space and consists of the total freight tonnes less iron ore exports, manganese exports, pipelines and, for the analysis that follows, stone and aggregate. The latter has been removed from the subsequent GFB analysis because it is typically a very short-distance movement of mostly construction aggregate, which is challenging to quantify and has extremely dispersed transport.

Flow segmentation

Manufactured goods, transported over long distances on road, present two opportunities for rail, namely (1) siding-to-siding freight, that is, long-distance freight that is usually moved from large manufacturing plants to other plants for further beneficiation; and (2) FMCG palletisable and containerisable freight, which can be transported through domestic intermodal solutions from private distribution centres through public intermodal terminals. Historically, the railway faced challenges in developing these solutions collaboratively with road. This impacts transport cost and competitiveness of industries in the Western Cape. The logistics challenges in South Africa and efforts to revitalise Transnet present opportunities for the public and private sectors to establish terminal and consolidation centers. These centers can facilitate the modal shift of palletised and containerised freight to alternative transportation modes. The development of domestic intermodal solutions for FMCG freight and the improvement of low-density rail lines serving rural areas can contribute to economic development in the Western Cape.

Economic forecast

Iron ore and manganese exports constitute the majority of the Western Cape's mining sector freight intensity[2]. Manufacturing and agricultural commodities from the Western Cape are transported over significantly longer distances than the mining commodities. The long-term strategy for the Western Cape should be to focus on developing and supporting efficient logistics solutions to support the growing manufacturing and agriculture sectors.

Freight Transport costs

In 2022, road freight accounted for 87% of the total transportation cost. The main road freight transport cost drivers were fuel (R33.3 billion; 44.2% of total cost), maintenance and repairs (R10.3 billion) and driver wages (R6.9 billion). Fuel cost increased by 50% against 2020 and 39.7% against 2021, driven by higher fuel prices. Given rail's high fixed cost, higher densities will reduce the mode's c/tonne-km cost. With its current low market share, the South African freight railway's challenge is that it needs a substantial modal shift from road to realise density benefit and further emphasises the significance of resolving the rail crisis in South Africa.

Externality cost

The total externality cost for road freight transport in the province amounts to R13.97 billion, which is 21.3% of current direct road freight transport costs. Road freight transport contributes 94% of the total freight transport externality cost of R14.87 billion, of which 80% is contributed by the four largest cost drivers (i.e., emissions, accidents, noise and congestion). These impact the general population while not being carried by the users of the service. Policy interventions could induce the internalisation of externality costs, and a systemic shift of rail-targetable freight to rail.

[2] Freight transport intensity is the ratio of freight transport demand (measured in tonne kilometres) and the economic output measured by Gross Domestic Product (GDP). Freight intensity is the quantum of freight transport required to achieve the same output. Freight transport intensity, for instance, for income received from gold mining versus income received from coal mining is very low. Meaning much less freight activity is required to achieve the same income. In a general sense high freight intensity means low returns for many tonne-kilometres. It can be reduced by higher value economies (services and high value products where the freight to product value ratio is low) or more efficient logistics (less kilometres for the same task, achieved through (inter alia) lower empty haul, better routing, better load factors).

Waste data gathering and analysis process

Waste does not contribute to the GDP directly, but it has an indirect impact since its transportation and disposal requires resources that could have been used for activities that contribute to the GDP.

The WC FDM™ waste forecast investigates a plausible relationship between waste generation and commodity demand. Waste Management and the logistics behind it are complex and waste generation is inherent not only to the consumption of goods but also to extraction and manufacturing processes. Therefore, a portion of transportable GDP will end up in landfills.

Given that the generation is explained by the demand for processed foods and beverages in the City of Cape Town, municipal waste reduction initiatives have seemingly been reducing the waste generation cumulatively by 34 000 tonnes per year since 2010. Municipal waste forecasts for the City of Cape Town, in the absence of additional waste reduction measures such as recycling and reuse, are expected to increase to 2.6m tonnes per year by 2052. Green waste generation is expected to double by 2052 based on the forecast for fertilizer demand in the City of Cape Town. Construction and demolition waste is expected to grow the fastest of the three waste streams based on the forecast of bricks and cement demand in the City of Cape Town.

The rate of change for waste generation for municipal, green and construction and demolition waste in the City of Cape Town was applied to provincial waste flows to produce a provincial waste forecast.

Air freight data

In 2022, there were 52 392 freight tonnes transported via Cape Town International Airport (CTIA), whereof 29 859 tonnes (57%) were exported and 22 533 tonnes (43%) were imported. This shows a growth in total trade of 25.7% (10 727 tonnes) from the 2021 volumes of 41 665 tonnes; and 64% (20 463 tonnes) from the 2020 volumes of 31 929 tonnes. However, air trade volumes are still lower than the 63 015 tonnes transported in 2019. CTIA predominantly imports and exports food in its role as a facilitator of international trade.

Apart from food-related commodities, the most air trade volumes in 2022 are perishable non-foods (4 338 tonnes); clothing and accessories (2 993 tonnes); machinery for general industrial uses (1 936 tonnes); other chemicals & products (1 342 tonnes) and pharmaceuticals (1 299 tonnes). While 2022's export and import volumes are much higher than in 2021, they are still lower than those traded in 2019.

Sufficient and reliable data is available for international air freight values and volumes, but limited data is available for domestic air freight volumes, specifically, data disaggregated by origin-destination and commodity. Government and industry stakeholders need to collaborate to improve the availability, reliability and level of detail of domestic air freight data, as this area in the market is key to economic job creation and competitiveness in the province. The presence of such a database would also allow for a more integrated and detailed air transport view in the WC FDM™, similar to current capabilities for other freight transport modes. Since competitive advantage and intellectual property are of considerable concern to many of the parties, both government and industry will need to ensure that data- sharing is beneficial to all stakeholders concerned.

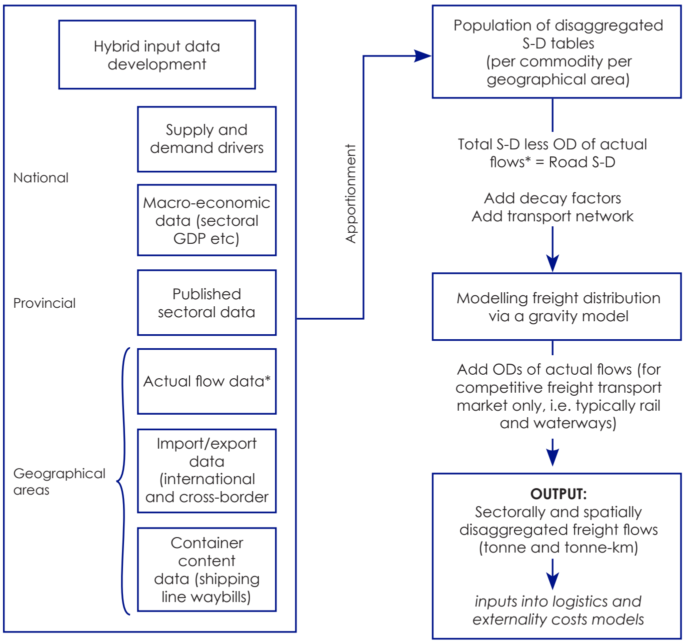
Scenario 1: Modal shift

The modal shift scenario is for commodities that have been identified as rail friendly, based on the density attributed to the origin and/or destination, packaging type and distance. As rail traffic becomes more dense, it becomes more efficient. An estimated 9.2% of the Western Cape's total freight transportation cost could have been saved in 2022 through modal shift. Increased potential for modal shift cost savings (when compared to the 2021 results) was driven primarily by the increase in the higher fuel price in 2022. The largest modal shift opportunity is for the N1 corridor freight. This could potentially save 8.4% of total transport cost. In 2022 the total transportation bill for freight touching the Western Cape was R75.4bn. The combined effect of the modal shift on the three corridors and core Western Cape traffic would have been a reduction of R6.91 billion or 9.2% in transport costs for the Western Cape.

Scenario 2: Terminal Network

The proposed terminal network for the Western Cape included a central super terminal or freight village, port connectivity, and network of handling points for containers, fruit, processed food, and fuel. The results are preliminary and intended to stimulate discussions for more accurate scenario development. The scenario assumes a functional rail system and sets volume targets for different terminals. Fruit terminals target full export volumes, while other terminals target natural modal shift volumes suitable for rail, plus an additional 50% of the remaining road volumes. The super terminal aims to handle palletized freight between the Western Cape and Gauteng, Limpopo, Mpumalanga, and Durban. The smaller container terminals target freight between the Garden Route and Gauteng, or the Garden Route and Cape Town, as well as cargo between Cape Town and Namibia or Namakwaland. Fruit terminals are located in Ceres, Caledon, and Vredendal, while processed food terminals are in Malmesbury, George, and Laingsburg. Fuel terminals are situated in Mosselbay and Cape Town. The estimated cost savings with the proposed terminal network in the Western Cape are significant, totaling R1.99 billion in transport costs and R1.97 billion in externality costs.

The process and key data sources that are used to develop the Western Cape Freight Demand Model[1] are indicated in Figure 1. The model produces supply and demand data which, in turn, defines freight flows in terms of origin, destination, commodity, volume and transport mode. The primary steps are the gathering and development of actual and modelled commodity-level data, disaggregation of this data to supply and demand per geographical district and modelling of the freight flows between origins (supply) and destinations (demand). These supply-and-demand tables are developed based on a hybrid approach that utilises the available datasets for each geography.



S-D = Supply and demand
OD = Origin-destination
** Rail, waterways, pipelines, conveyor belts (where applicable)*

Figure 1: Adapted from key data sources and process detail of the FDM (Havenga and Simpson, 2018)

The South African national model was first developed and used in 1998. The model was improved in 2006 to become a completely repeatable model that captures freight flows between 372 districts for 83 commodities for all modes of transport on land within SA, for export, import and domestic freight, over a 30-year forecast horizon. The WC FDM™ was developed for the first time in 2017/18, based on the national FDM™, with the objective to add richer and more refined known data for the province and enable the development of more refined strategies.

The methodology for developing the FDMs (both national and provincial) consists of two steps: (1) econometric modelling and (2) flow modelling.

Econometric modelling

This modelling approach is required to develop multi-commodity, multi-regional national freight demand models (Havenga and Simpson, 2018). Econometric models identify and analyse cause- and-effect and correlative relationships between the total freight demand and its drivers. Figure 2 shows the econometric modelling steps.

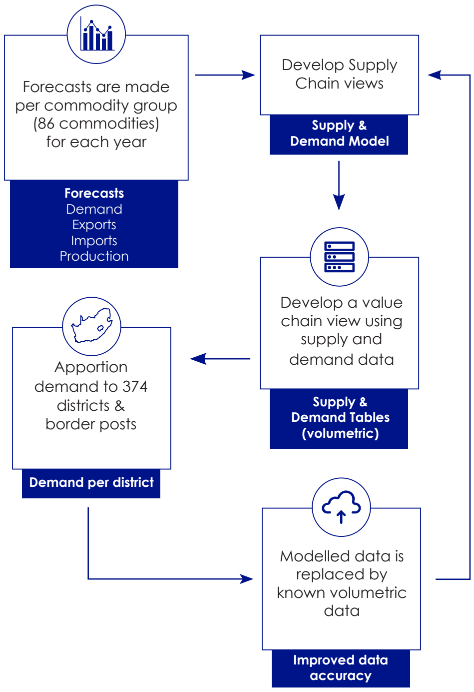


Figure 2: Econometric model

Supply and demand are forecasted 30 years into the future. This provides likely high and low growth scenarios. These forecasts are based on assumptions regarding the international economic outlook, Gross Domestic Product (GDP) growth, inflation, national capital spending, population growth, and various other forecasting factors.

Flow modelling

Flow modelling uses the supply and demand values of the econometric model to model the movement of freight between supply areas (origins) and demand areas (destinations) throughout the country, for all commodities and modes.

The input data is created by subtracting the volume of known flows per geographical district (rail, pipeline, conveyor) from the total supply and demand volumes. The balance of supply and demand is then modelled as road flows, by means of gravity modelling.

Gravity modelling is based on the premise that freight flows between geographical districts are determined by supply and demand volumes for each commodity, and by a measure of transport resistance[2] per commodity.

Distance and travel time are the most common measures of transport resistance. Road cost components, such as diesel consumption and truck wear-and-tear, also typically have a linear relationship with distance and time. A distance-decay function describes the attraction value between origins (supply) and destinations (demand). The decay factor determines the slope of the decay function and its relative change over distance and time. Distance decay varies from one commodity to another based on many characteristics, including its value, nature and utility.

[1] Western Cape Freight Demand Model utilises in part the "FDM" (a registered trademark of GAIN Group (Pty) Ltd)
[2] Transport resistance is a commodity's propensity to be transported over a specific distance, with that propensity being determined by the utility and desirability which is traded-off with transport cost as a percentage of delivered cost. Propensity is, therefore, estimated through a decay function for each commodity in question. In cases where the transport cost percentage is very low, the commodity will move even if the utility and desirability is low.

Low value, bulk commodities that generate a transport demand disproportionate to their value tend to have a sharp rate of decay (i.e., they tend not to be transported over long distances), while the impact of distance is smaller for higher-value commodities, thus suggesting low decay parameters (mostly used for manufactured and end-use agriculture commodities, that is, heterogeneous agglomerations with use that is more dispersed over a number of geographical districts).

Figure 3 shows the Flow Model.

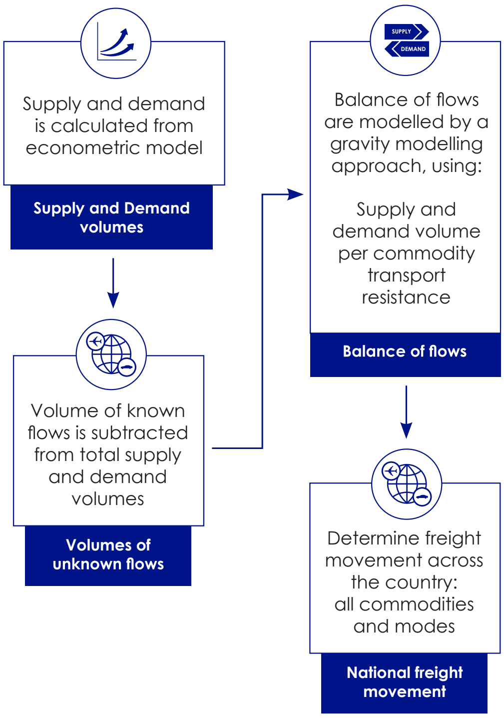


Figure 3: Flow Model

The Western Cape Freight Demand Model (WCFDM)

The WCFDM is confined to those Western Cape geographical districts from the national FDM (42 magisterial districts, 3 ports) for which freight either originates, is destined for, or moves within the district. The model is a complete set of origin and destination freight movements, per commodity (currently 86 commodities) and per transport mode (road, rail, pipeline and international air freight). A geographic representation of the WCFDM districts is presented in Figure 4.

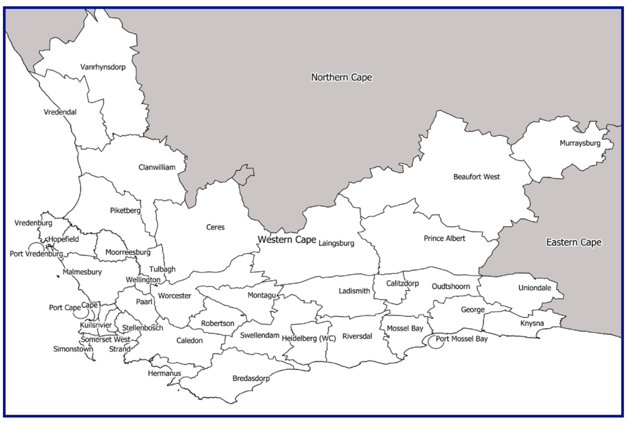


Figure 4: Geographical districts within the Western Cape

Data sources

During the development of the WCFDM, the following data sources were used:

- Inputs from participating Logistics Service Providers (LSP);
- Transnet Freight Rail data;
- Transnet National Ports Authority data – bulk and containers;
- Western Cape specific data: agriculture crops, waste and mining data;
- Publicly available data for industry and businesses.
- Western Cape specific Air freight data

Figure 5 and the text box below provide a summary and explanation of the datasets used and updated:

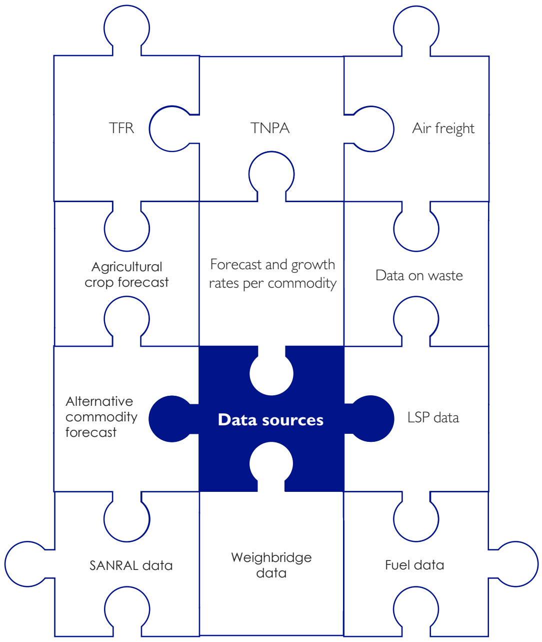


Figure 5: Data Sources

1. Forecasts and growth rates: Revised in line with the national FDM for imports, exports, production, intermediate demand and final demand/consumption in WCFDM.
2. Waste: Data collected and included in the model.
3. Participating Logistics Service Provider (LSP): Company origin-destination freight movements were further interrogated and verified with more detailed cost and tariffs.
4. Liquid fuels and the imports and exports of refined petroleum products: Additional research was conducted and comparisons made between data from industry, the South African Petroleum Industry Association (SAPIA) and the Department of Energy.
5. Weighbridge data: Used to validate WCFDM flows. It largely confirmed the modelled WCFDM road flows.
6. South African National Roads Agency Limited (SANRAL) data: New SANRAL data for analysis and comparison with modelled data on the N1, N2 and N7.
7. Agricultural data: Latest data, including estimated current crops and future plantings and yields, were incorporated.
8. Air freight data: International airfreight handled by Cape Town International Airport included but not yet integrated with other modes of transport in the FDM as the origin destination (OD) detail is not available.

Refer to Chapter 6 of Havenga et al (2020), Havenga (2013) and Chapter 8 of Havenga (2007) for a more technical description of the FDM model:

Havenga, J.H. (2007), 'The development and application of a freight transport flow model for South Africa', dissertation presented for the degree of Doctor of Philosophy (Logistics Management), Stellenbosch: University of Stellenbosch.

Havenga, J.H. (2013), 'The importance of disaggregated freight flow forecasts to inform transport infrastructure investments', Journal of Transport and Supply Chain Management, Vol. 7 No. 1, pp. 1-7.

Havenga, J.H., Witthoft, I.E., De Bod, A. and Simpson, Z. 2020. *From Logistics Strategy to Macrologistics: Imperatives for a developing World. London. Kogan Page Publishers.*

Havenga, J.H. and Simpson, Z.P. (2018), 'National freight demand modelling: a tool for macrologistics management', International Journal of Logistics Management, Vol. 29 No. 4, pp.1171-1195, https://doi.org/10.1108/IJLM-11-2017-

In this chapter, Western Cape freight is discussed from two perspectives, namely, total freight and general freight business (GFB). GFB is defined as the competitive market space and consists of the total freight tonnes less coal-, iron ore-, and manganese exports, pipelines and (for the subsequent analysis) stone and aggregate. The latter has been removed from the GFB analysis because it is typically a very short-distance movement of mostly construction aggregate, which is challenging to quantify and has extremely dispersed transport. Previously iron ore on the export line, which was used for Saldanha Steel, was included in GFB. This iron ore, however, uses the same dedicated line and station infrastructure as the export iron ore and was revised to be non-GFB freight, as it was not mode competitive.

Modal split

Total road and rail freight with an origin or destination in the Western Cape in 2022 is shown in Figure 1 and amounted to 142.3m tonnes, representing a negligible increase from the 142.2m tonnes in 2021.

The total tonnes per sector for road and rail are given in Figure 2. The waste data[1], consists of municipal waste, organic waste, and construction and demolition waste. The largest concentration of waste generation and transportation occurs within the CoCT, which has a substantial impact on local flows.

GFB volumes are shown in Figure 3, with the dominance of manufacturing being evident. The 2022 data shows an increase for road tonnes across all sectors from 2021: agriculture (3%), mining (11%) and mManufacturing (1%) increase. Agriculture freight by rail grew by 15%, while mining and manufacturing contracted by 21% and 22% respectively. Rail lost 11% market share of GFB volumes in 2022.

[1] Available waste data has been integrated, despite not fully visible in terms of all routing and movements, as well as limited detail on other waste categories such as hazardous waste.

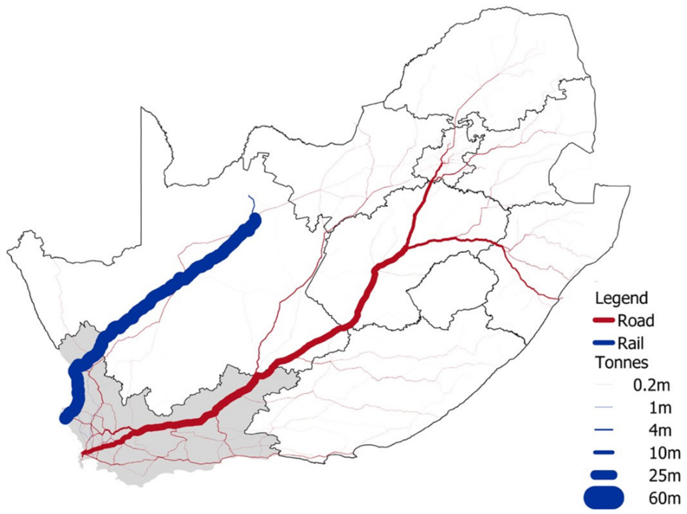


Figure 1: Total freight with an origin or destination in the Western Cape scaled to iron ore export line (2022)

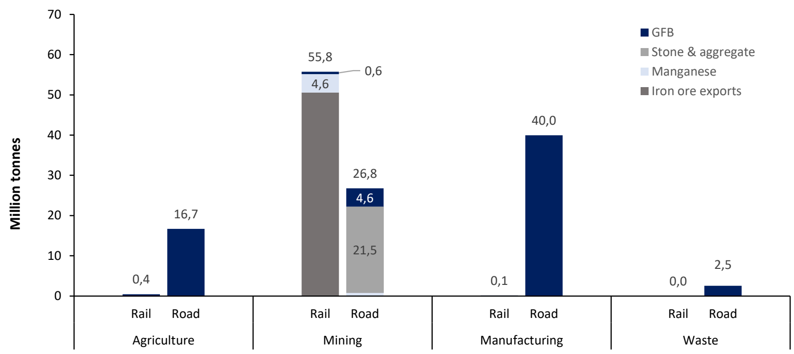


Figure 2: Total road and rail tonnes per sector in the Western Cape (2022)

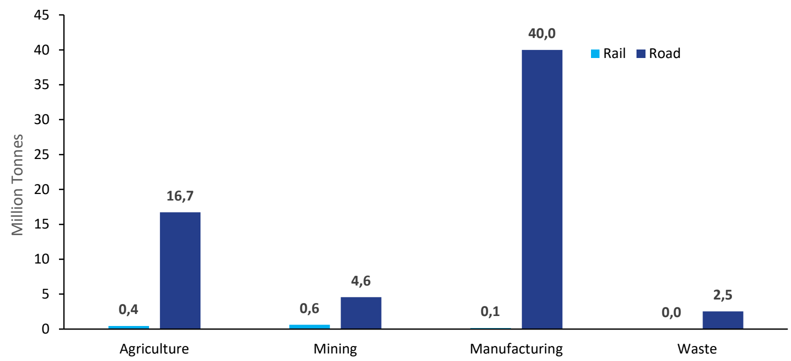


Figure 3: GFB road and rail tonnes per sector (2022)

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Figure 4 (to its own scale) shows GFB rail freight movements that touch the Western Cape.

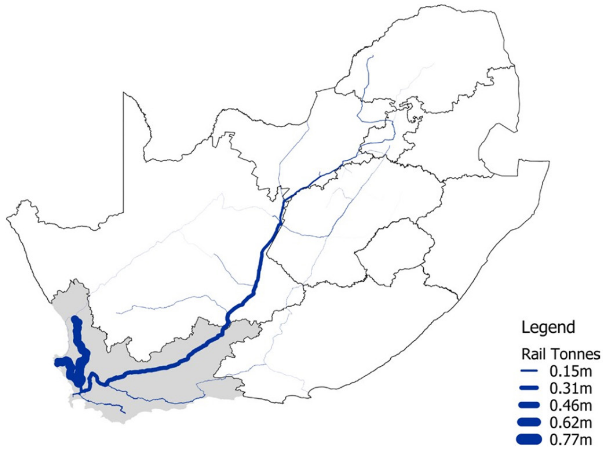

Figure 4: GFB rail freight that touches the Western Cape (2022)

Agricultural dry bulk like wheat, maize and barley are still transported on rail to a limited extent but year-on-year volumes have slightly increased; for instance, barley, maize, wheat were 27 955 (17%), 21 623 tonnes (12%) and 2 557 tonnes (17%) more, respectively. Grain sorghum increased by 1 836 tonnes (36%), which now accounts for 16% of the market share, (down from 25% before,because road grew faster).

Fruit presents a major opportunity that has not been realised due to the lack of consolidation facilities, rail service levels and capacity. Apart from coal and iron ore needed for the plant, rail is basically only used at Namakwa Sands (Tronox), at a stable rate of half a million tonne per annum. Rail has not been able to recover the limestone, granite and other manufacturing loss from 2021. Despite iron & steel more than doubling on rail, 11 196 up from 4 693 it is still less that 3% of the 2019 volumes, due to the closure of Saldanha Steel. Figure 4's contrast with Figure 1 highlights the limited role of rail, once the bulk coal and iron ore have been removed.

Apart from road and rail freight, there are two movements of commodities in pipelines amounting to 1.35m tonnes. This increase (from 0.9m tonnes) from 2021 is due to crude oil being imported via Mossel Bay. The remaining movements were gas from the offshore production wells to the Mossgas production platform (0.15m tonnes).

Commodity splits per mode

Freight volumes per commodity per mode for Western Cape-related GFB freight can be seen in Figure 5.

The commodity "Other Agriculture" mostly consists of unmanufactured agricultural animal feed (namely lucerne and hay).

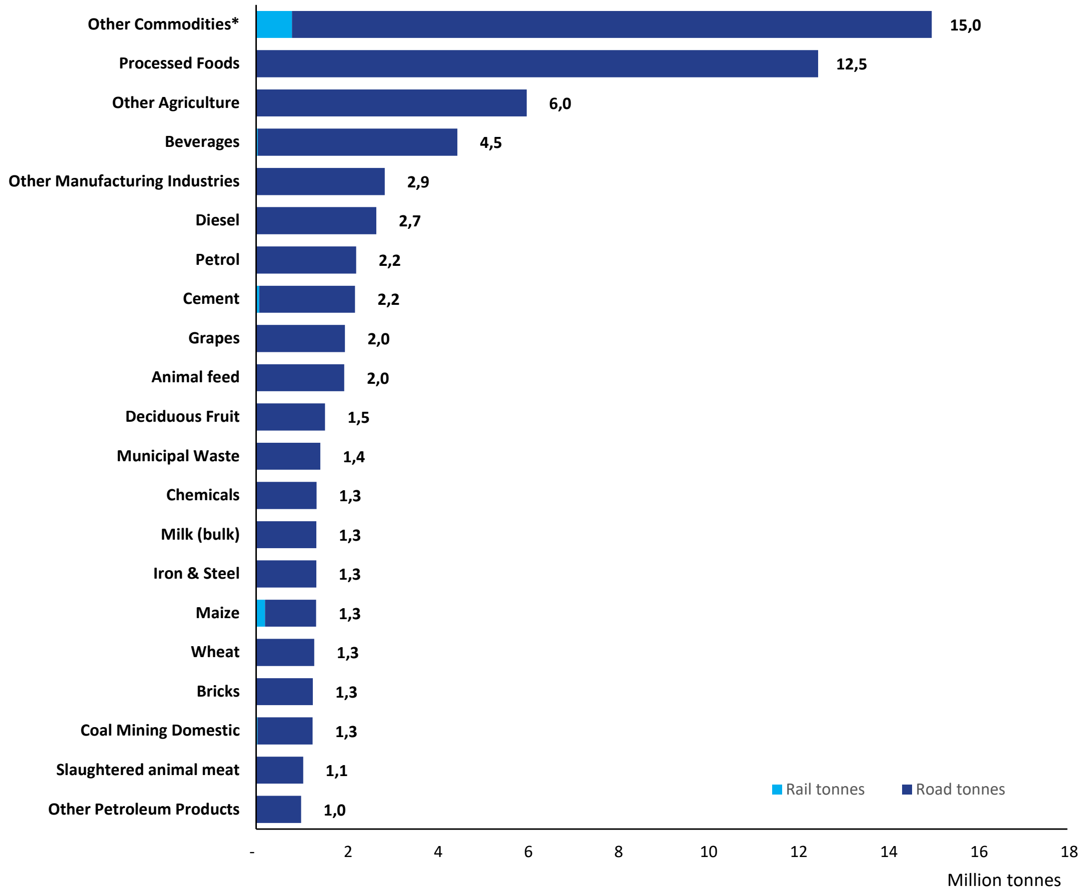

Figure 5: Western Cape related GFB freight volumes per commodity per mode (2022)

* See section 15-1, for detail on "other manufacturing industries" and the grouping "other commodities"

Table 1 provides the Western Cape rail volumes and market share for commodities that have rail market share

Table 1: Rail volumes and market share (2022 and 2021)

Commodity on rail	Rail volumes (thousand tonnes)		Rail Market Share	
	2022	2021	2022	2021
Ilmenite (Titanium ore)	428.3	406.8	50%	56%
Maize	199.7	178.1	15%	12%
Barley	195.9	168.0	62%	59%
Titanium slag	-	165.9	0%	49%
Zircon	107.9	112.6	70%	75%
Cement	69.8	58.2	3%	3%
Beverages	36.8	47.7	1%	1%
Coal Mining Domestic	29.9	36.3	2%	3%
Fertilizer	8.5	34.2	2%	6%
Rutile	31.4	28.8	18%	15%
Chemicals	4.0	21.8	0%	2%
Gypsum	14.4	20.7	12%	13%
Wheat	17.7	15.1	1%	1%
Grain Sorghum	6.9	5.1	16%	25%
Iron & Steel	11.2	4.7	1%	0%
Diesel	-	1.0	0%	0%
Other Manufacturing Industries	-	-	0%	0%
Granite	-	-	0%	0%
Limestone	-	-	0%	0%
Metal products, machinery and electronic equipment	-	-	0%	0%

Globally, the largest rail market share has historically been in low-value, bulk commodities with large parcel sizes (i.e., consignments). The traditional belief was that these freight categories serve rail economics better; the bulk mining and agricultural commodity market share was usually the highest. However, intermodal traffic, and especially domestic intermodal, has grown faster in most developed countries' railways over the last decade.

Rail has a captive market in bulk mining exports; the current success of their business, therefore, depends largely on exogenous factors, such as global economic growth, strong commodity prices, and proximity to transport facilities. Globally, rail service providers have realised that the most stable growth opportunity is fast-moving consumer goods (FMCG), which can be palletised, containerised, and moved through a domestic intermodal solution. This should also be the case for South Africa, especially for the Natal and Cape corridors. Rail transportation becomes more efficient than road over long distances, given a sufficient level of density. Therefore, based on the long average distance freight travels on the Cape Corridor, it presents the biggest opportunity.

Despite rail tonnes in the Western Cape growing faster than national rail tonnes since 2010, it was not resilient to the drop in rail freight in 2020, however, it did recover some freight in 2021 but declined again in 2022, as can be seen in Figure 6.

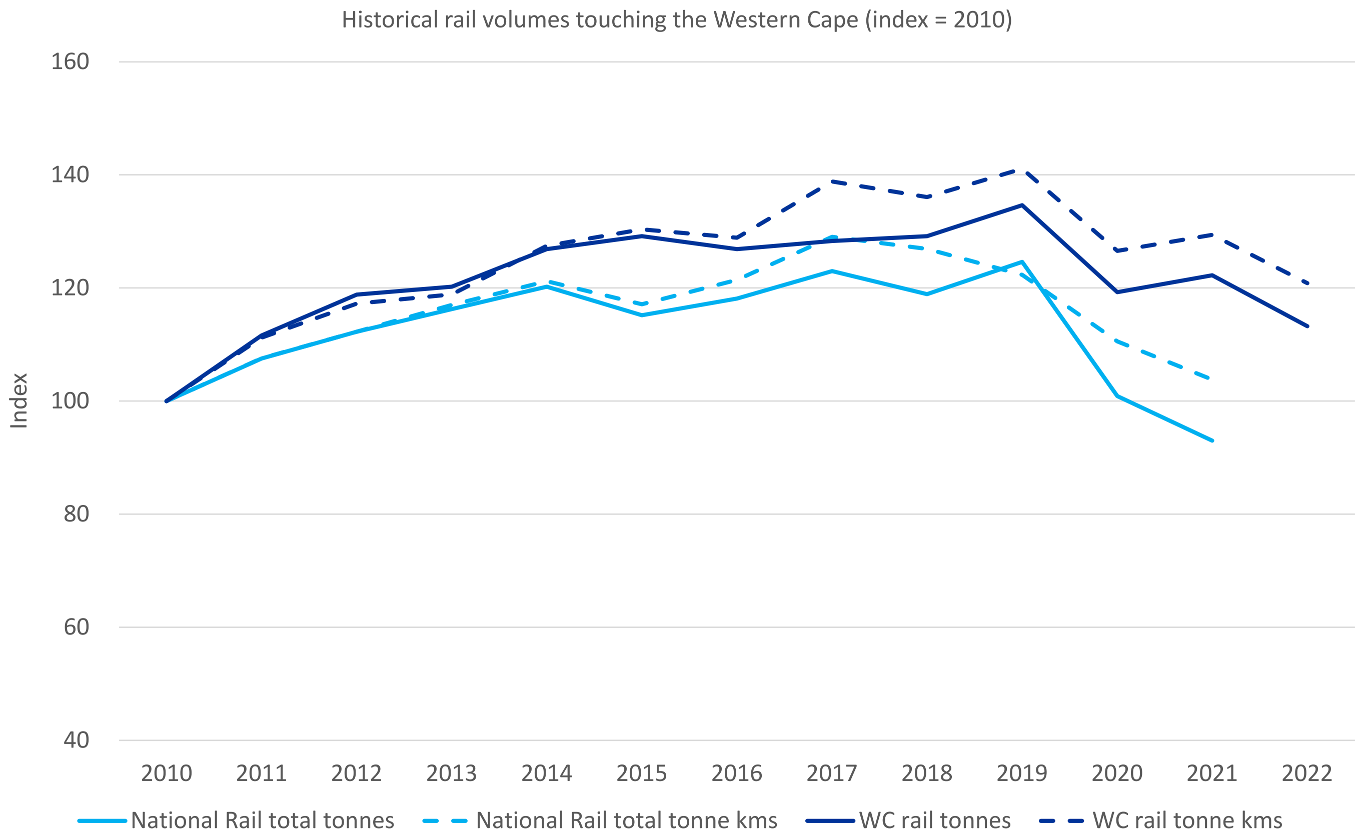

Figure 6: Time series of indexed rail tonnes and tonne-kms from 2010 to 2022 (index = 2010)[2]

[2] National Rail volumes unavailable for 2022

Highlights

- Total road and rail freight (2022) with an origin or destination in the Western Cape amounted to 142.3m tonnes, showing a negligible increase from the 142.2m tonnes in 2021
- Modal share in the Western Cape remained unchanged in 2022 (excluding air freight and pipelines) is 60% (road), 39% (rail) for total freight and 98% (road), 2% (rail) for GFB freight, marking no significant change from 2021.
- The mining sector is dominant due to export iron ore.
- Pipeline freight amounted to 1.35m tonnes, of which most was crude oil moving from Mossel Bay port to the PetroSA refinery.
- Air freight via Cape Town International Airport amounted to 52 392 tonnes, whereof most movements were related to exports. Overall, food was the most prevalent air freight commodity (31%).
- Fruit on rail presents a major opportunity that has not been realised due to the lack of consolidation facilities and service levels.
- The mining sector is dominant in GFB rail freight volumes, which is primarily driven by Namakwa Sands activity.
- Rail volumes shows an increase across all three sectors in 2022.
- Opportunities exist for rail transport of long-distance GFB freight in the Western Cape.

The total 143.8m tonnes of freight touching the Western Cape is made up of 83.9m mining tonnes (58%), 40.3m manufacturing tonnes (28%), 17.1m agricultural tonnes (12%), and 2.5m waste tonnes (2%) (Refer to Figure 1).

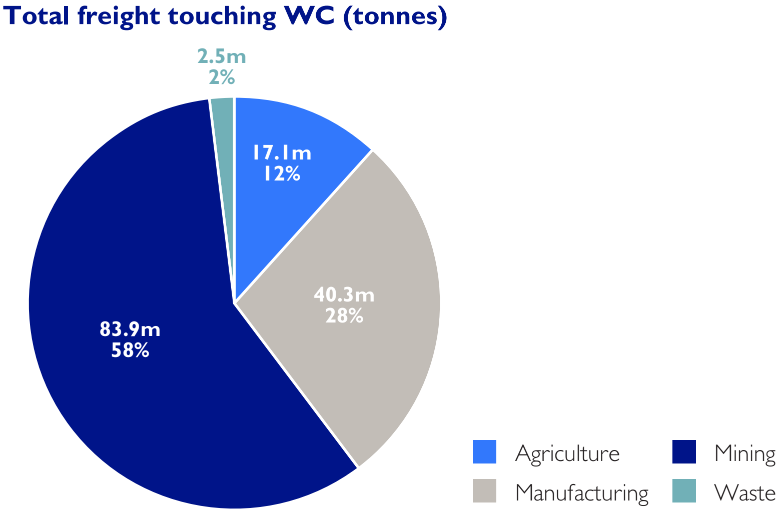

Figure 1: Total freight-flows per sector (tonnes 2022)

The Western Cape General Freight Business (GFB)[1] of 66.4m tonnes consists of 22.3m tonnes intra-Western Cape freight, 24.3m tonnes transported to other provinces and 19.8m tonnes received from other provinces.

Intra-Western Cape freight shows an increase of 1.7m tonnes for 2022 compared to 20.6m tonnes in 2021 . The tonnes transported to other provinces decreased by 0.2m tonnes (24.5m tonnes in 2021) and freight received from other provinces increased by 1.4m (18.3m tonnes in 2021). These flows are shown per sector in Figure 2. Waste was modelled as a separate sector to determine its impact on the Western Cape's freight flow economy. Waste is not moved to or from other provinces and, is thus only an intra-provincial flow. At 11% (2.5m tonnes), it forms a substantial part of intra- provincial tonnes.

In 2022, the Western Cape received 1.3m more tonnes of mining commodities from other provinces than in 2021. The manufacturing freight sent to other provinces in 2022 saw a decrease of 0.6 million tonnes compared to 2021. Agriculture commodities sent and received increased by 0.3m and 0.03m tonnes respectively.

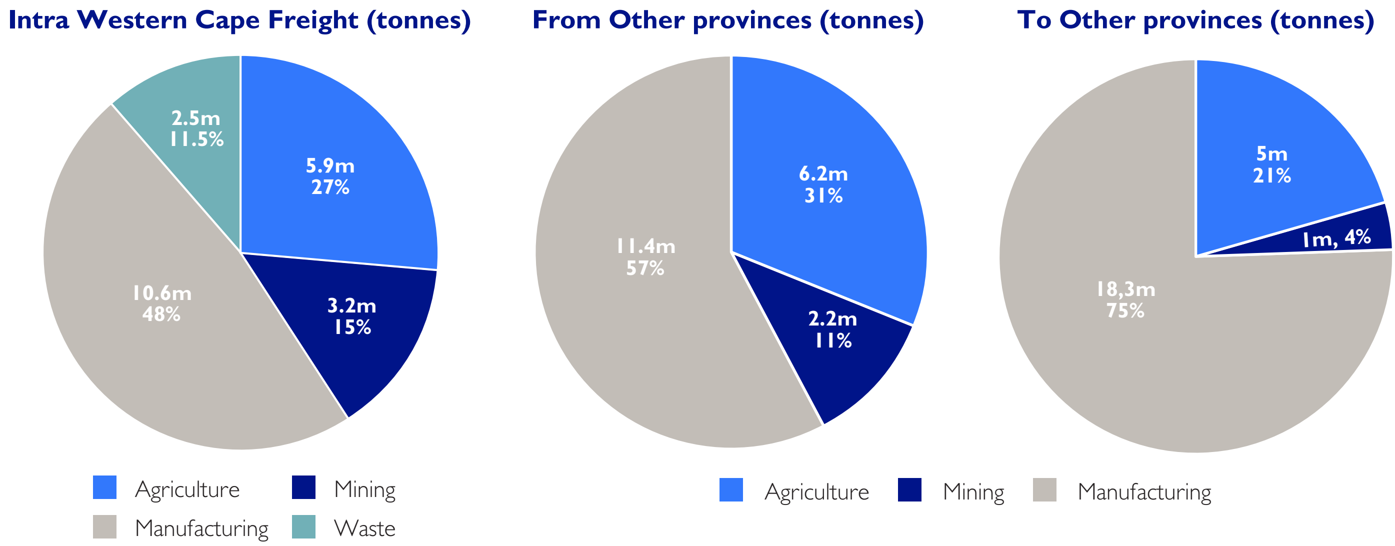

Figure 2: Provincial GFB freight-flows per sector (tonnes 2022)

[1] GFB is defined as the competitive market space, and consists of the total freight tonnes less iron ore exports, manganese exports, pipelines and, for the analysis that follows, stone and aggregate. The latter has been removed from the subsequent GFB analysis because it is typically a very short-distance movement of mostly construction aggregate, which is challenging to quantify and has extremely dispersed transport.

An industry breakdown of the Western Cape manufacturing sector is shown in Figure 3. It shows the intra-Western Cape manufacturing tonnes, as well as the manufacturing tonnes flowing to other provinces, to depict the manufacturing base of the province. Of the total 28.9m tonnes of manufacturing commodities that originate from the Western Cape, only 10.6m tonnes are distributed inside the province while 18.3m tonnes are sent to the rest of the country. The largest commodity group is processed foods, which contributes 30%, followed by beverages (11%). Provided that there is no structural change to the South African economy, processed foods should continue to be the mainstay of the Western Cape's manufacturing sector.

KwaZulu-Natal again dominates as the Western Cape's main GFB trading partner, followed by Gauteng as shown in Figure 4. The Western Cape receives 6.2m tonnes (31.1%) of its GFB freight from KwaZulu-Natal and 3.0m tonnes (15.4%) from Gauteng. Of all the GFB freight originating from the Western Cape, 5.4m tonnes (22.2%) are destined for Gauteng and 4.7m tonnes (19.2%) for KwaZulu-Natal. If it was not for the Port-related trade with KZN, Gauteng would have been the Western Cape's biggest trading partner, because 22.6% of trade with KZN is related to the Port of Durban.

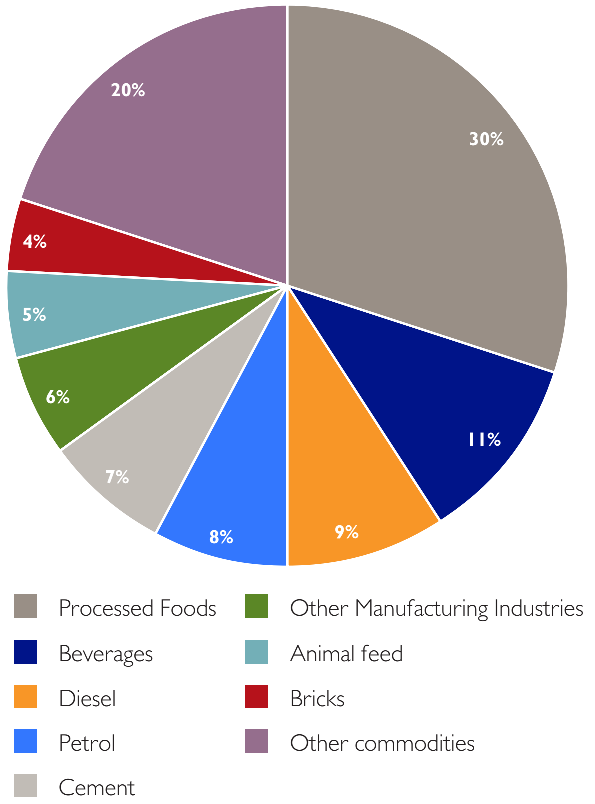

Figure 3: Manufacturing commodities with origin Western Cape (intra-provincial and outgoing, 2022)

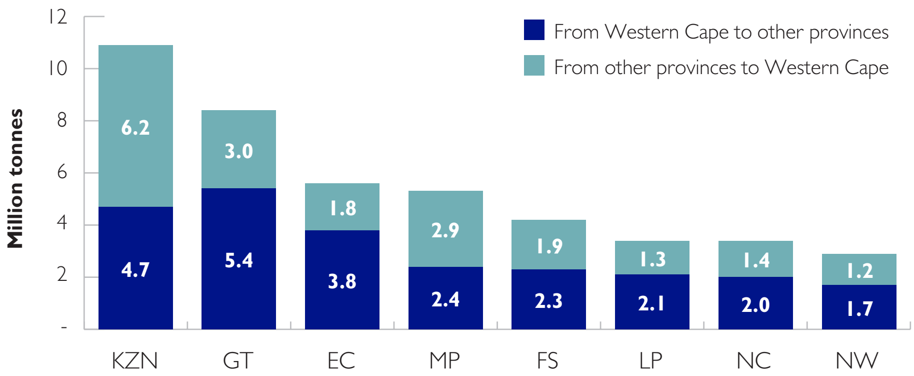

Figure 4: Western Cape inter-provincial GFB freight (2022)

Highlights

- A total of 143.8m tonnes of freight touches the Western Cape (2022) and is made up of 83.9m mining tonnes (58%), 40.3m manufacturing tonnes (28%), 17.1m agricultural tonnes (12%), and 2.5m (2%) waste tonnes
- The Western Cape GFB freight (66.4m tonnes) is split between intra-Western Cape freight (22.3m tonnes), freight transported to other provinces (24.3m tonnes) and freight received from other provinces (19.8m tonnes).
- Waste is an intra-provincial flow only and amounts to 2.5m tonnes (11% of intra-provincial flow).
- Almost half (48%) of intra-Western Cape freight and 75% of freight to other provinces are manufacturing commodities, amounting to 28.9m tonnes.
- The largest commodity group in the Western Cape's manufacturing sector, is processed foods (30%), followed by beverages (11%).
- KwaZulu-Natal is the Western Cape's main GFB trading partner, followed closely by Gauteng. If it was not for the Port related trade, Gauteng would have been the Western Cape's biggest trading partner, because 22.6% of trade with KZN is related to the Port of Durban.

To determine corridor freight for the N1, N2 and N7, the districts of South Africa are divided into five (5) zones, of which the first four are illustrated in Figure 1:

1. N1 Corridor;
2. N2 Corridor;
3. N7 Corridor;
4. Core Western Cape (districts within which freight movements are not considered to be on any of the national corridors);
5. Metropolitan (a combination of the Cape Town Metropolitan area and its peripheral areas); and
6. Non-corridor (any freight movement not clustered according to the cluster rules)

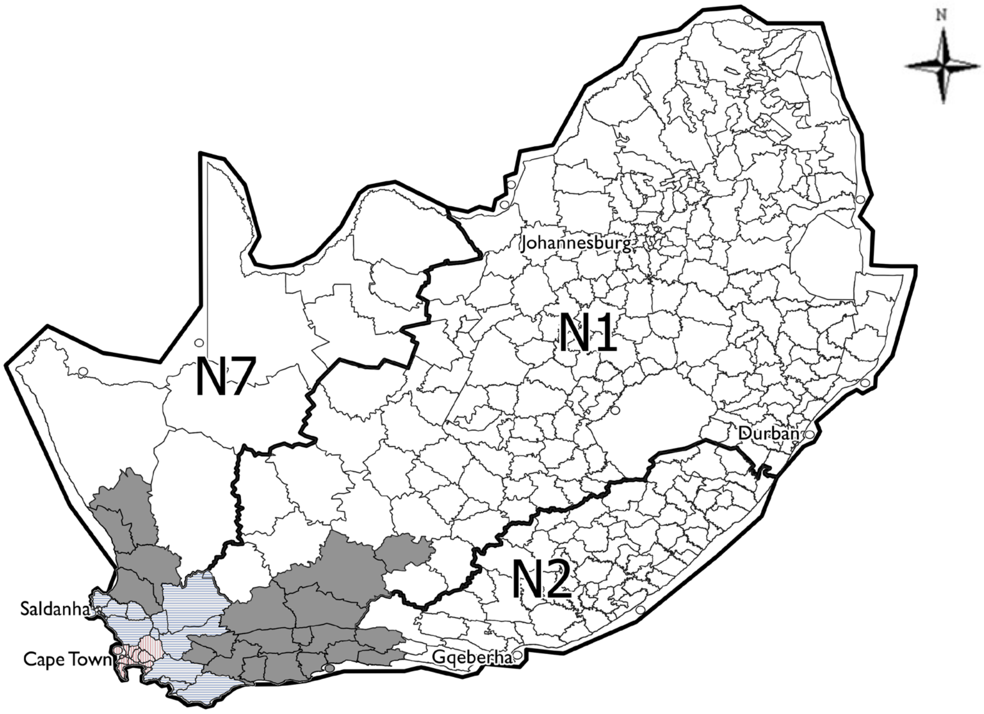

Figure 1: Corridor definitions for Western Cape freight

As shown in Figure 2, freight in the Core Western Cape zone is further sub-divided into Cape Town Metropolitan freight.

The Cape Town Metropolitan (Zone 5) freight is defined as freight that has its origin and destination inside the metropolitan areas.

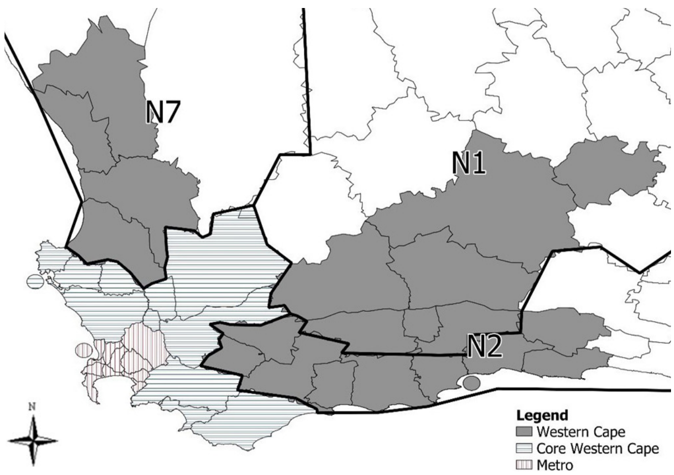

Figure 2: OD pairs for Cape Town Metropolitan freight

The Origin-Destination (OD) pairs are clustered into corridors by applying the following rules:

Cluster rules

- If the origin and destination are both within either the N1, N2 or N7 zones, the OD pair is assigned to that corridor.
- If the origin and destination are within different corridor zones, the OD pair is not assigned to a corridor.
- If the origin and destination are both within the core Western Cape zone, the OD pair is not assigned to a corridor.
- If either the origin or destination is within the core Western Cape zone, the OD pair is assigned to the corridor zone in which the non-core Western Cape origin or destination is.

Table 1 provides total road and rail freight in tonnes and tonne-kms, with the percentage split for each, per zonal grouping.

Table 1: Total road and rail freight (tonnes and, tonne-kms) per zone (2022)

	Total Tonnes			**Total Tonne-kms**		
Zonal Grouping	Road tonnes (million) (% of zone freight)	Rail tonnes (million) (% of zone freight)	Total (million)	Road tonne-kms (billion) (% of zone freight)	Rail tonne-kms (billion) (% of zone freight)	Total (billion)
N1 Corridor traffic	29.8 (99.1%)	0.3 (0.9%)	30.0	41.3 (99.3%)	0.3 (0.7%)	41.6
N2 Corridor traffic	9.3 (99.8%)	0.02 (0.2%)	9.4	5.6 (99.8%)	0.01 (0.2%)	5.6
N7 Corridor traffic	4.2 (6.9%)	55.7 (93.1%)	59.9	1.8 (3.4%)	51.5 (96.6%)	53.4
Metropolitan traffic	24.8 (100%)	0.0 (0%)	24.8	0.5 (100%)	0.0 (0%)	0.5
Core Western Cape	8.5 (97.1%)	0.3 (2.9%)	8.7	0.6 (96.7%)	0.02 (3.3%)	0.6
Non-corridor traffic	9.5 (99.4%)	0.06 (0.6%)	9.5	10.6 (99.2%)	0.1 (0.8%)	10.7
Total	**86.0 (60.6%)**	**56.3 (39.6%)**	**142.3**	**60.4 (53.8%)**	**51.9 (46.2%)**	**112.4**

Table 2 provides total GFB[1] road and rail freight in tonnes and tonne-kms, with the percentage split for each, per zonal grouping.

Table 2: GFB road and rail freight in tonnes and tonne-kms per zone (2022)

	GFB Tonnes			**GFB Tonne-kms**		
Zonal Grouping	Road tonnes (million) (% of zone freight)	Rail tonnes (million) (% of zone freight)	Total (million)	Road tonne-kms (billion) (% of zone freight)	Rail tonne-kms (billion) (% of zone freight)	Total (billion)
N1 Corridor traffic	29.5 (99.1%)	0.26 (0.9%)	29.8	41.3 (99.3%)	0.3 (0.7%)	41.5
N2 Corridor traffic	8.2 (99.7%)	0.02 (0.3%)	8.2	5.6 (99.8%)	0.01 (0.2%)	5.3
N7 Corridor traffic	3.7 (86.6%)	0.57 (13.4%)	4.2	1.4 (84.1%)	0.3 (15.9%)	1.6
Metropolitan traffic	7.2 (100%)	0.00 (0%)	7.2	0.2 (100%)	0.0 (0%)	0.2
Core Western Cape	6.2 (96.1%)	0.25 (3.9%)	6.4	0.5 (95.9%)	0.02 (3.3%)	0.5
Non-corridor traffic	9.0 (99.3%)	0.06 (0.7%)	9.1	10.6 (99.2%)	0.1 (0.8%)	10.7
Total	**63.8 (98.2%)**	**1.2 (1.8%)**	**64.9**	**59.2 (98.9%)**	**0.7 (1.1%)**	**59.9**

Table 3 displays the GFB freight, excluding domestic iron ore and coal.

Table 3: GFB (also excluding domestic iron ore and coal) road and rail freight in (tonnes and tonne-kms) per zone (2022)

	GFB (also excluding domestic iron ore and coal) Tonnes			**GFB (also excluding domestic iron ore and coal) Tonne-kms**		
Zonal Grouping	Road tonnes (million) (% of zone freight)	Rail tonnes (million) (% of zone freight)	Total (million)	Road tonne-kms (billion) (% of zone freight)	Rail tonne-kms (billion) (% of zone freight)	Total (billion)
N1 Corridor traffic	28.8 (99.1%)	0.3 (0.9%)	29.1	40.2 (99.3%)	0.3 (0.7%)	40.5
N2 Corridor traffic	8.2 (99.7%)	0.02 (0.3%)	8.2	5.3 (99.8%)	0.01 (0.2%)	5.3
N7 Corridor traffic	3.6 (86.4%)	0.6 (13.6%)	4.2	1.4 (84.0%)	0.3 (16.0%)	1.6
Metropolitan traffic	7.2 (100.0%)	0.0 (0.0%)	7.2	0.2 (100.0%)	0.0 (0.0%)	0.2
Core Western Cape	6.1 (96.0%)	0.3 (4.0%)	6.4	0.5 (95.9%)	0.02 (4.1%)	0.5
Non-corridor traffic	8.6 (99.6%)	0.03 (0.4%)	8.6	10.0 (99.8%)	0.02 (0.2%)	10.0
Total	**62.6 (98.2%)**	**1.1 (1.8%)**	**63.7**	**57.5 (99.0%)**	**0.6 (1.0%)**	**58.1**

[1] GFB is defined as the competitive market space, and consists of the total freight tonnes less iron ore exports, manganese exports, pipelines and, for the analysis that follows, stone and aggregate. The latter has been removed from the subsequent GFB analysis because it is typically a very short-distance movement of mostly construction aggregate, which is challenging to quantify and has extremely dispersed transport.

When compared to volumes of previous years, the rail tonnages on the N1 and N7 corridors shows a slight increase in volumes of barley, maize and cement on the N1 zonal grouping, and ilmenite and rutile on the N7 zonal grouping. GFB Freight on the N2, N7, Metropolitan, and Core Western Cape corridors experienced minor growth, with increases of 5.8%, 4%, 10.7%, and 1.8%, respectively, when compared to the figures from 2021. In contrast, freight on the N1 remained nearly static. The tonne-km view confirms a smaller rail market share, indicating that longer distance freight is increasingly being transported by road. This means that a long-distance market exists that can potentially benefit from rail's economies of scale, given that rail operators can provide a competitive service.

Table 4 shows the breakdown of GFB (excluding road domestic iron ore and coal) road freight per zone. Note that 46.1% of this freight travels on the N1 road corridor, with an average distance travelled of 1 394 km.

Table 4: GFB (excluding road domestic iron ore and coal) road freight per zone (2022)

Zonal Grouping	Road tonnes (million)	Percentage of road traffic	Average Travel Distance (km)
N1 Corridor traffic	28.8	46.1%	1 394
N2 Corridor traffic	8.2	13.0%	646
N7 Corridor traffic	3.6	5.8%	380
Metropolitan traffic	7.2	11.5%	27
Core Western Cape	6.1	9.8%	81
Non-corridor traffic	8.6	13.8%	1 162
Total	**62.6**	**100.0%**	

Highlights

- Total freight touching the Western Cape the only corridor with significant rail volumes is the N7 corridor, but this is due to the dedicated iron ore corridor.
- Corridor GFB freight is dominated by road, with: 99.1% market share on the N1 corridor; 99.7% market share on the N2 corridor and 86.6% market share on the N7 corridor
- The average travel distance of road freight on the N1, N2, N7, Metropolitan and Core Western Cape corridor is 1 394 km, 646 km, 380 km, 27km and 81km respectively.
- Due to the low rail market share, modal shift opportunities exist for long-distance road freight in the Western Cape (more detail in Scenario 1: Modal shift).

Background to the segmentation of freight flows based on economic structure

The segmentation definitions are illustrated in Figure 1. A pit refers to a source where raw materials are extracted from the earth. Ore from the pit can be transported to a bulk terminal, port or directly to a plant for beneficiation. Beneficiated ore can be transported to another plant (intermediate demand), directly to metropolitan or rural areas, to distribution centres (DC) for consolidation before it is transported to a metropolitan or rural area, or it can be exported.

Based on this view of freight flow segmentation, class 1 (T1) represents freight flow from a pit to a bulk port (exports) and from a bulk port to a plant (imports). T2 refers to direct flows from pit to plant. T3 are flows from one plant to another for beneficiation, to a distribution centre for final consumption, or between plants and MPTs for exports and imports. T4 represents commodity flows between distribution centres (typically over long distances between metropolitan areas) for final domestic consumption, or between DCs and port container terminals for exports and imports. T5 represents all flows to and from rural areas; T5a flows originate at a rural tank or silo, while T5b are all flows destined for a rural distribution centre.

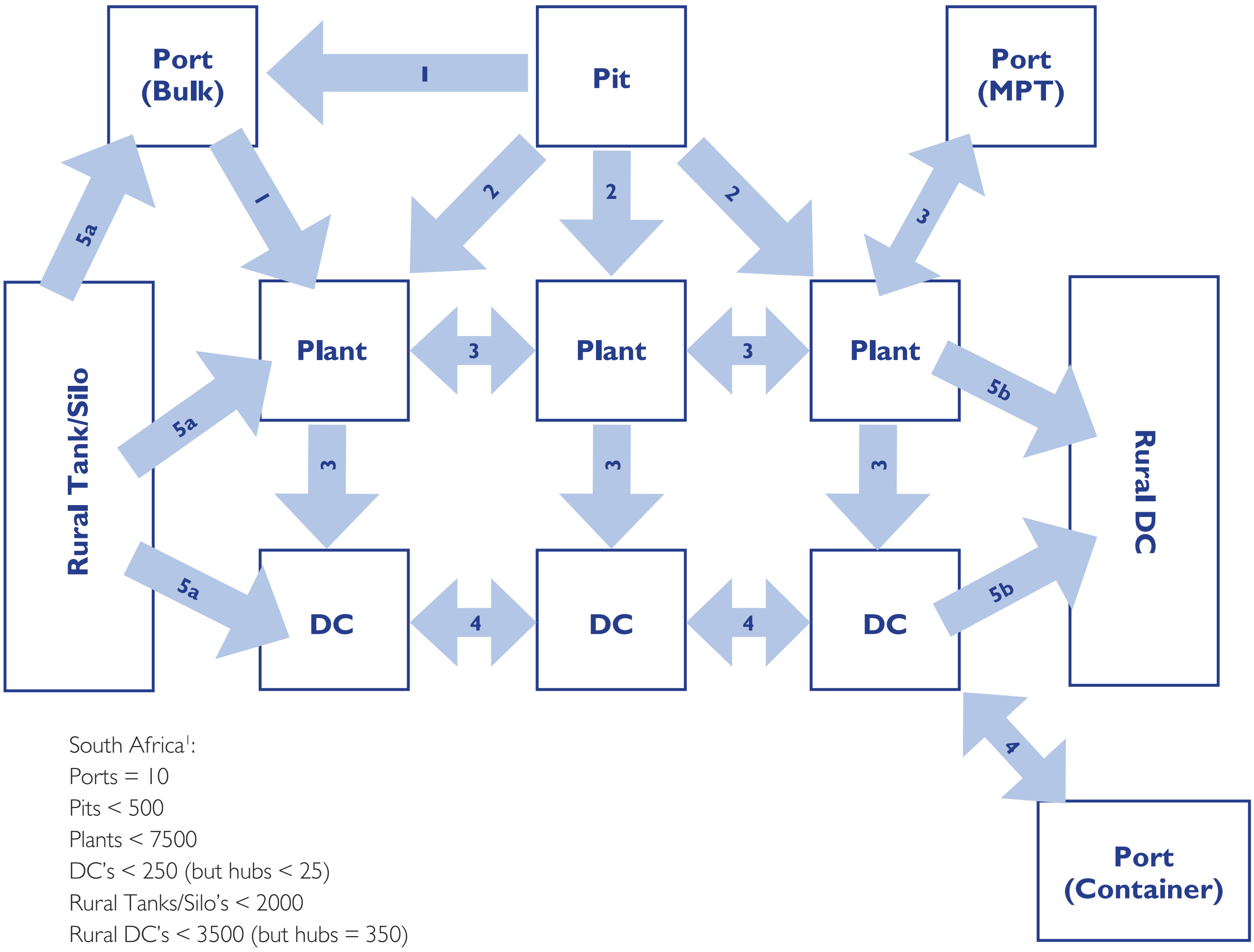

Figure 1: The different typologies of freight flows[2]

As depicted in Figure 2, these segments can be summarised in terms of extraction, intermediate manufacturing, final manufacturing and consumption, and can be divided into imports, domestic flows, and exports. The transportation of domestic consumer goods from points of final manufacturing to points of consumption account for 37% of the Western Cape's total transportation cost. Seventy-five percent of the 18% of extraction to exports refers to the handling of iron ore and manganese exports in Saldanha.

[1] Indication of the number of nodes, terminals and distribution centres in South Africa.

Beneficiation therefore represents a significant growth opportunity, changing the Western Cape's status from a "handler" of cargo to an industrial centre. If not for these minerals, the province's beneficiated exports and long-distance imports of final products would exceed the national average, indicating a pressing need to solve the cost concerns of this freight flow segment.

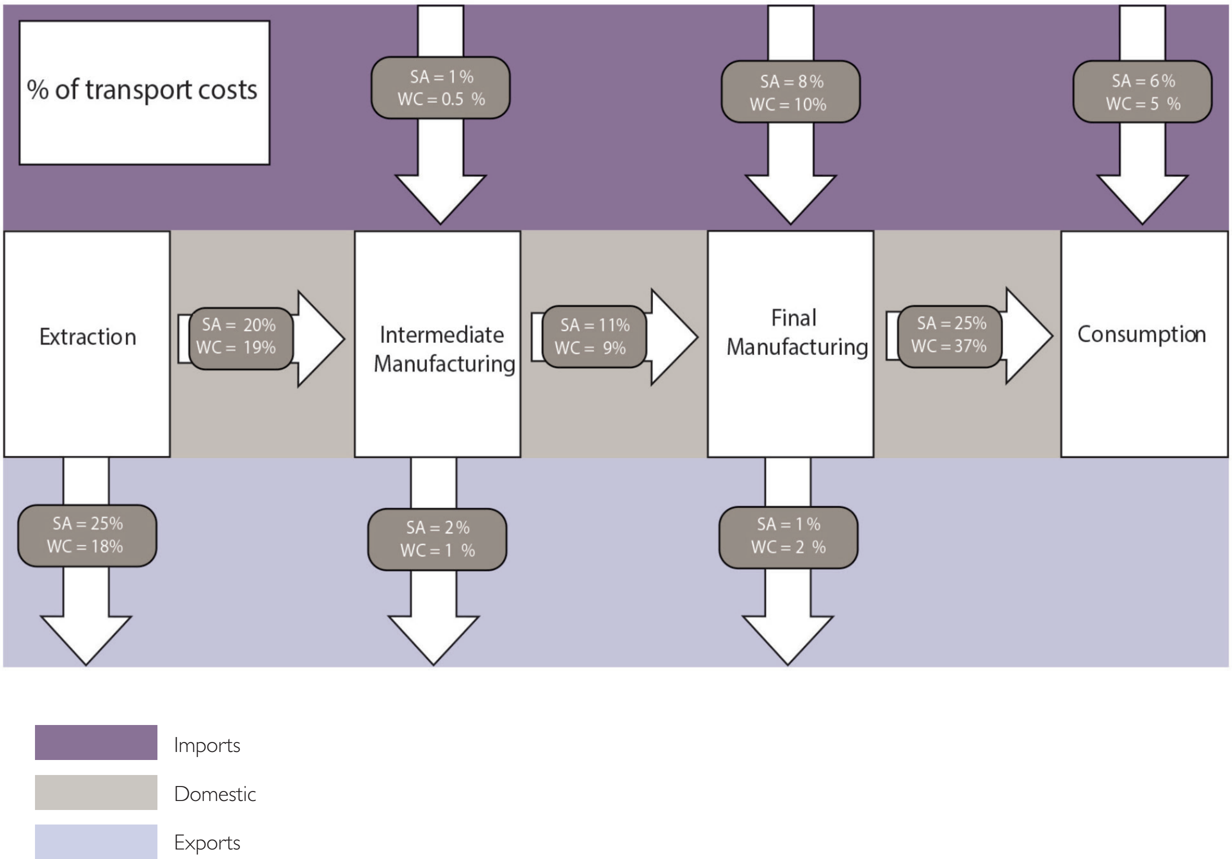

Figure 2: National and Western Cape transport cost per freight flow segment (2022)[2]

Western Cape freight flows informed by economic structure

An analysis of the 2022 modal split in tonnes for General Freight Business (GFB)[3] in the Western Cape confirms that the province transports relatively more manufactured goods, over long distances on road (refer Figure 3). The data highlights two specific opportunities for rail. The "siding-to-siding" market defines long distance freight that is usually moved from large manufacturing plants to other plants for further beneficiation. In these cases, dedicated sidings are usually the best rail solution. Rail sidings are in place in South Africa, but many have fallen into disuse and have large maintenance backlogs. The potential devolution of low-density rail lines in the near future can offer opportunities for the province as these lines often serve rural areas and improving them can contribute to economic development in the province[4].

The other opportunity is palletisable and containerisable fast-moving consumer goods (FMCG) freight. This freight can be transported from private distribution centres through public intermodal terminals. This domestic intermodal opportunity is still absent in South Africa's rail/road service offering, due to management and resource challenges within Transnet, as well as caution from road hauliers owing to the impact on their traditional business models. The inability of the railway to develop these solutions collaboratively with road to capture long-distance FMCG freight is hampering the competitiveness of the Western Cape's industries owing to the impact on transport costs. The modal shift scenarios identify cost savings, should rail be able to realise these opportunities (see section on "Scenario 1: Modal Shift").

The logistics challenges currently facing South Africa and efforts to revitalise Transnet, present opportunities for the public and the private sector to proactively establish terminal and consolidation centres for facilitating the modal shift of palletised and containerised freight. (Refer to the section discussing "Scenario 2: Terminal Networks" for more details.)

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[2] Havenga, J.H. (2012), "Rail renaissance based on strategic market segmentation principles", Southern African Business Review, Vol. 16 No. 1, pp. 1-21.
[3] GFB is defined as the competitive market space, and consists of the total freight tonnes less iron ore export line, manganese exports, pipelines and, for the analysis that follows, stone and aggregate. The latter has been removed from the subsequent GFB analysis because it is typically a very short-distance movement of mostly construction aggregate, which is challenging to quantify and has extremely dispersed transport.
[4] South African Freight Logistics Roadmap, 2023

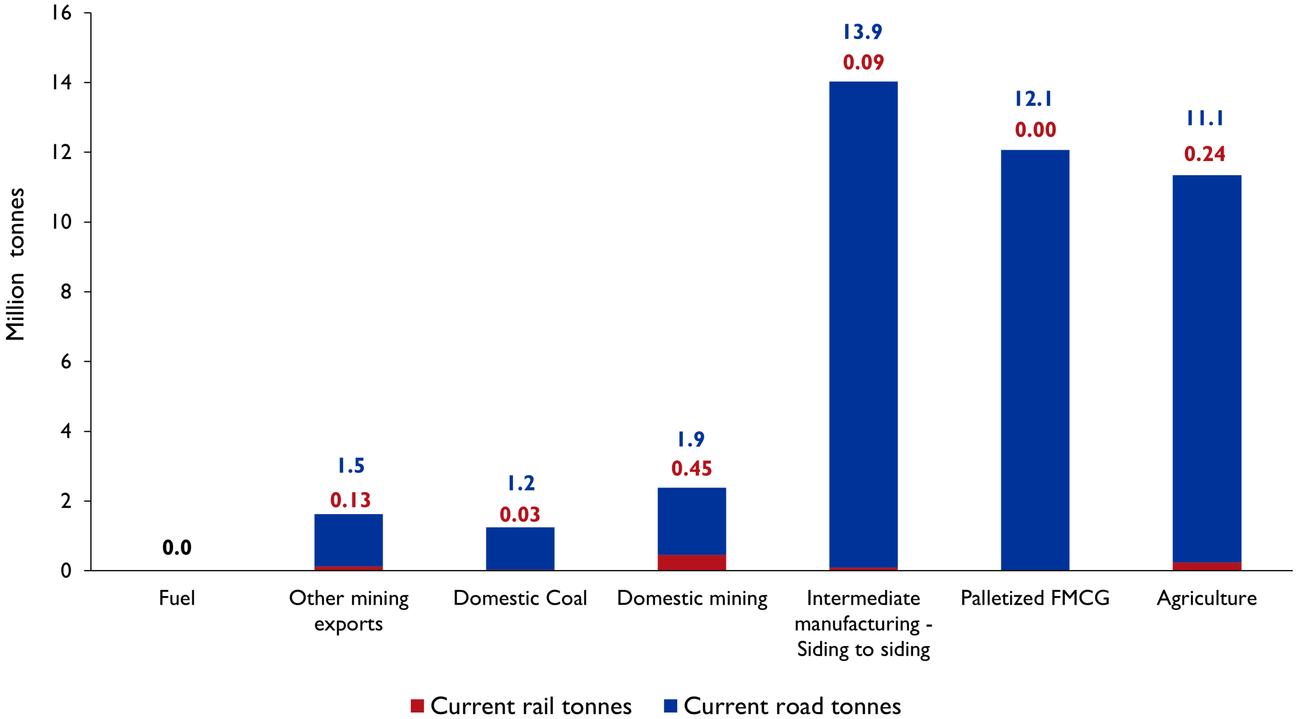


Figure 3: GFB road and rail tonnes per market segment in the Western Cape for 2022

Highlights

- Manufactured goods, transported over long distances on road, constitute a large volume of the Western Cape GFB freight.
- This presents two opportunities for rail:
  1. Siding-to-siding freight, that is, long-distance freight that is usually moved from large manufacturing plants to other plants for further beneficiation; and
  2. FMCG freight which can be palletised and containerised, and transported through domestic intermodal solutions.
- The inability of the railway to develop these solutions collaboratively with road to capture the long-distance FMCG freight impacts transport costs, and hence hampers the competitiveness of industries in the Western Cape.
- South Africa's logistics challenges and efforts to revive Transnet, create opportunities for the public and private sector to establish terminal and consolidation centres, promoting the shift of palletised and containerised freight to alternative transportation modes.

Economic forecast

The WC FDM™ considered 2028 and 2053 as the forecast years in the analysis. The total tonnes forecast per sector for 2028 and 2053 are given in Figure 1, both (a) with and (b) without the iron ore and manganese exports.

The inclusion of the impact of COVID-19 in long-term economic forecasts is important for providing a more realistic assessment of the economic landscape. For the 2022 base year forecasts, 2020 to 2022 was considered a recovery period and not sustained/new economic growth. Covid was a lag on the economy. This economic forecast did not take into account the potential for continued economic volatility and disruptions in the supply chains, however future forecasts should start to consider global climate change perspectives.

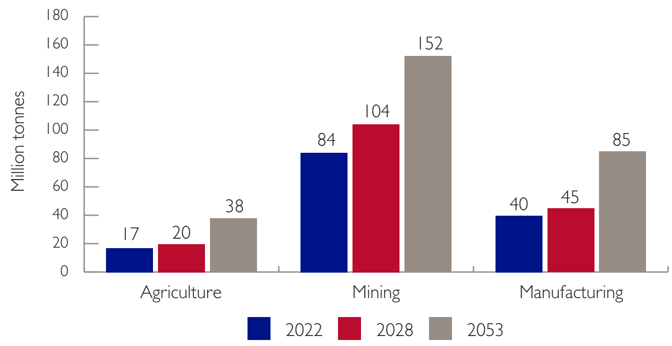
The forecast for mining, when considering GFB, is predominantly driven by sand mining on the West Coast, which is very short-haul and specific. This is evident from Figure 2, which shows the forecasted Western Cape freight flow tonne-kms by sector both (a) with and (b) without the iron ore and manganese exports. Evidently, manufacturing tonne- kms currently far exceed the mining tonne-kms when the export lines are excluded.

As shown by Figure 2, manufacturing commodities for the Western Cape are transported over long distances. The forecast also illustrates that there is a ceiling on the export lines[1]. This highlights a systemic problem with the long-term sustainability of the railway lines: their profitability depends on the global demand for South African minerals, despite their high economies of scale. The investment into the export lines was necessary, for both medium-term rail growth and the South African economy; however, it is not a long-term sustainable strategy, for either the railway or South Africa. The economic forecast suggests that the long-term strategy for the Western Cape should focus on developing and supporting efficient logistics solutions to support the growing manufacturing and agriculture sectors, which supply freight to the rest of the country over long distances.

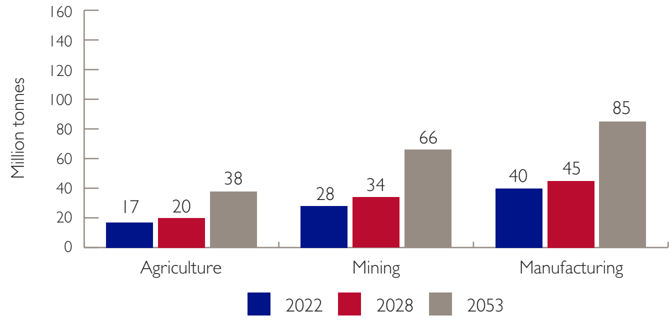
[1] Anglo American, estimated a reserve life for Sishen till 2035 in its 2021 Kumba Ore Reserves and Mineral resources report (Anglo American, 2021).

Highlights

- Iron ore and manganese exports constitute the majority of the Western Cape's mining sector freight intensity.
- Manufacturing and agricultural commodities from the Western Cape are transported over significantly longer distances than the mining commodities.
- The manufacturing sector is forecast to generate the largest logistics demand in the absence of the ring-fenced export lines.
- The economic forecast suggests the development of infrastructure that will support the growing manufacturing and agriculture sectors.

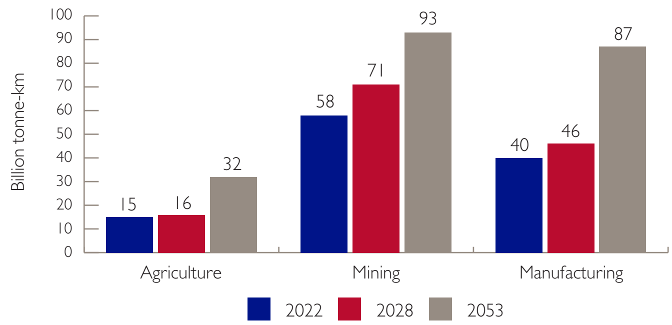


(a) Total Western Cape

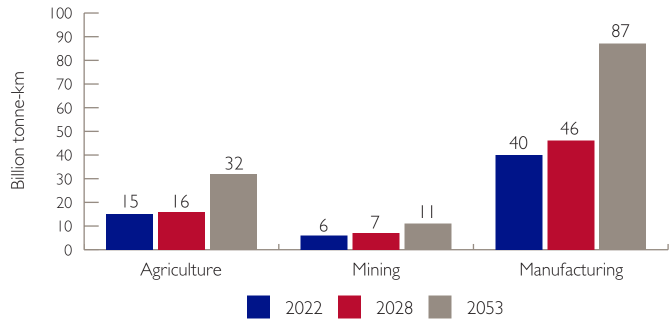


(b) Excluding export iron ore and manganese

Figure 1: Total Western Cape freight flow forecast per sector (tonnes 2022)



(a) Total Western Cape



(b) Excluding export iron ore and manganese

Figure 2: Total Western Cape freight flow forecast per sector (tonne-km 2022)

Freight transport cost

The freight transport cost model forms part of the national logistics cost model, which was developed by the research team to quantify the direct[1] national logistics costs. The freight transport costs are available on a district-to-district basis per commodity, and can be used to measure the impact of modal changes; they therefore indicate what the impact of certain macro-economic infrastructure- related decisions would be on the economy[2]. For the refinement of the WCFDM, actual road freight transport rates were confidentially received from Logistics Service Providers (LSP) and used to refine the fixed and variable road freight transport cost elements.

The different road transport cost elements are determined by vehicle type which, in turn, is determined by commodity type, typology, and route of travel. A commodity's "preferred" vehicle type will change as each of these variables changes. Once the vehicle type and volume are assumed, the cost elements can be assigned. The approach is based on the core freight transport cost drivers, namely, weight and distance travelled. Each movement can also be attributed to one of 41 possible vehicle combinations, based on the commodity's destination and distance travelled. A separate rate per tonne-kilometre for each of the 41 vehicle types is applied. Other costs that are determined by the typology, such as fuel costs and toll fees, are defined and calculated separately.

Average annual distances and working days are applied to the various combinations, based on current practice, including waiting time for loading and unloading or any other relevant factors. As examples, the sources of information include logistics and supply chain service providers, FMCG manufacturers, retail groups, agricultural food producers, processors, timber plantations, the furniture industry, car carriers, the construction industry, mining (for transport of mined commodities, but excluding transport for mining activities). Payloads for each category are based on transport regulations. Where return loads are not possible or practical, the load factor is set at 50% (e.g., raw milk and liquid petroleum). In other cases, inputs from transporters and suppliers provide an acceptable average load factor. Emerging changes, such as making use of larger pallet footprints in secondary distribution, are taken into account. Few transporters and fleet owners can actually afford to operate without a return leg, which means that load factors increase with distance where commodities and return volumes (as determined in the FDM) allow.

Within these cost measurement combinations, different cost drivers exist for fuel, wages, repairs and maintenance, depreciation, capital cost, insurance, tyres, tolls roads and licence fees.

It is necessary to distinguish between ***costs*** and **tariffs**.

Costs refer to the actual costs that are directly incurred by the freight movement. That will be the total cost for in-house transport as well as outsourced transport. In the case of outsourced transport, a margin is added to the cost, in order to charge a tariff.

Tariffs reflect both the margins and strategic pricing decisions of a transport company, in addition to cost recovery. A transport company, for example, could decide to fund return legs by only recovering variable cost, thus transporting freight below total cost. For the purposes of informing policy and investment decision-making, actual costs are used in modelling national and provincial logistics costs; the impact of margins and of strategic decision-making on costs can then be modelled in scenarios.

Road costs and rail tariffs are typically used (refer to Table 1).

Table 1: Overview of underlying aspects of costs and tariffs for road and rail transport:

	Road	Rail
Costs	Can be calculated with a fixed and publicly available schedule[3].	Estimated using a well-researched algorithm. (Even the railway service providers find it difficult to apply activity- based rail costing. This is a global phenomenon, due to the very high fixed cost nature of rail business).
	The freight owner incurs road cost by utilising in-house road transport.	In-house rail transport is not possible.
Tariffs	Estimated through fieldwork and interviews in order to add margins to costs.	Precisely available for all consignments in South Africa, but confidential at the detail level.
	The freight owner incurs road tariffs by outsourcing road transport.	The freight owner incurs rail tariffs by utilising Transnet.

[1] Direct costs are internal, monetised costs of inputs and labour that are used in the provision of freight transport. These differ from externality costs that affect third parties who may not be direct users of freight transport services.
[2] For further detail on the methodology and macroeconomic application, refer to: Havenga, J.H. (2010), 'Logistics costs in South Africa: The case for macro-economic measurement', South African Journal of Economics, Vol. 78 No. 4, pp. 460-478.
[3] Data from the Road Freight Association provides detailed fixed and variable cost drivers for the different vehicle classes used in the WC FDM™.

Rail tariffs are used due to the complexity of calculating actual rail costs. Furthermore, freight owners cannot incur actual rail costs since freight rail transport cannot be provided "in-house" (Freight owners in South Africa do not own their own railway). Actual rail tariffs are confidential and cannot be disclosed, but were used in an aggregated way. In cases where rail costs are required for scenario analysis, costs are estimated based on an algorithm developed in conjunction with Transnet[4]. Road cost and tariffs are both possible for freight owners as only about 51% of freight transport in South Africa is outsourced. Where freight transport is provided in-house, the actual cost is all that is incurred by the freight owner. Where it is outsourced, the tariff incurred is made up of the transport supplier's cost and mark-up. For the purposes of comparison, an 8%[5] profit margin was assumed for road transport costs in 2022 (see Figure 2). One of the major drivers of efficiency in road freight is outsourcing, which also contributes to South Africa being more efficient than BRICS partners in comparisons such as the World Bank Group's Logistics Performance Index (LPI).

The drivers for road freight transport costs are described in Table 2.

Table 2: Cost drivers for road freight transport for 2022

Cost driver	Description
Fuel	The price of fuel is based on the weighted average annual price for 2022, taking cognisance of the different inland and coastal prices, for 500 parts per million (ppm) diesel. Bulk rebates are ignored.
Driver's wage	Driver and assistant wages vary considerably across the country based on vehicle size, primary and secondary distribution tasks, region, operators, and the structure of remuneration packages. All assumptions, in line with wage agreements between the Road Freight Employers' Association and the National Bargaining Council for the Road Freight and Logistics Industry, include an allowance for company contributions, but exclude overtime and bonuses.
Repairs and maintenance	The assumed cost of maintenance is based on current vehicle manufacturer maintenance contract rates, expected economic component life and industry experience. The assumptions consider the complexity of each task, including typical operating conditions such as roads, topography, and traffic density. Repair and maintenance costs for refrigeration operations are calculated in hours.
Depreciation	An annual depreciation percentage is considered per vehicle combination, as well as a residual value per vehicle.
Cost of capital	All estimates are based on a cost estimate for new vehicles and trailing equipment. The initial cost of vehicles, trailers, bodies, and auxiliary equipment (such as refrigeration units) is based on the average of published selling prices of such items in the modelled year in question, less known fleet discounts.
Insurance	Insurance cost assumes that the operator has a low risk rating. Premiums are currently set at 7% of the purchase price for vehicles, equipment, and trailers.
Tyres	Tyre life is based on the typical casing life that is obtained in the various operations.
Toll roads	Assumed route-incurred toll fees are applied proportionally to the number of trips that each movement accounts for, according to the size structure of the vehicle used for its toll fee class.
Vehicle licences	Licence fees for vehicles and trailers are based on the average license fees of each province, as the licensing province of trucks is unknown, and nationally distributed[6].

[4] Note that actual rail costs at a consignment level are very difficult to calculate, even for the railways.
[5] This is based on confidential interviews.
[6] This average assumption is deemed sufficient, given the current status of road freight user- pay charges.

In 2022, road freight transport accounted for 87% of the total estimated freight transportation cost. The main cost drivers were fuel (R33.3 billion; 44.2% of total cost), maintenance and repairs (R10.3 billion), and driver wages (R6.9 billion)[7]. These costs are shown in Figure 1 and Table 3. Fuel cost increased by 50% against 2020 and 39.7% against 2021, driven by higher fuel prices. The 2020 FDM report stated the possibility that this figure could nearly double in the short term and it almost realised.

Figure 2 outlines the cents per tonne-km (c/tonne-km) for road and rail. The impact of the export lines on rail rates is evident. Given rail's high fixed cost, higher density means that the mode's c/tonne-km cost will decrease with each additional tonne- km of activity over the same track length. With its current low market share, the South African freight railway's challenge is that it needs a substantial modal shift from road to realise these density benefits and further emphasises the significance of resolving the rail crisis in South Africa. (see section 9 on externality costs).

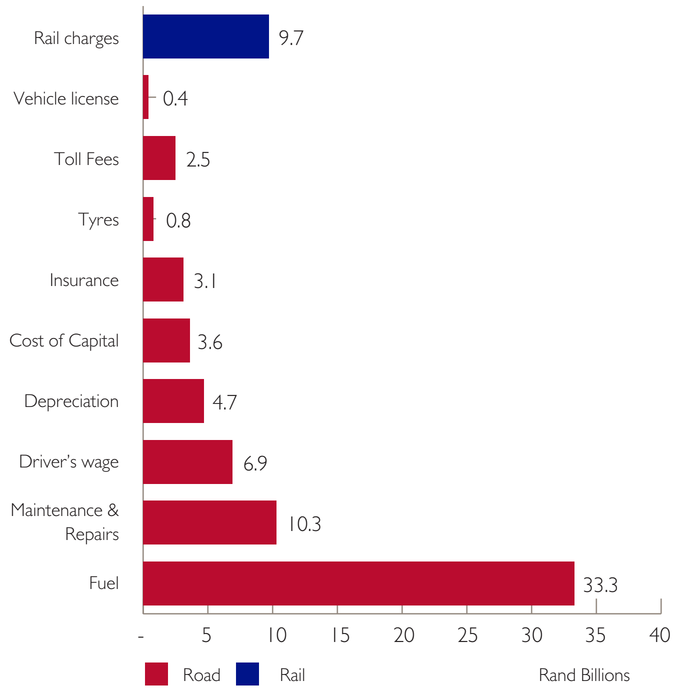


Figure 1: Transport cost components per mode for Western Cape freight (2022)

[7] The model, as was stated, includes actual rail and pipeline tariffs (pipeline tariffs are not shown on the graph, as they are negligible — only 0.02% of total transport costs in the Western Cape).

Table 3: Transport cost drivers

Cost driver	Cost (R bn)	% of total
Fuel	33.3	44.2%
Maintenance & Repairs	10.3	13.7%
Driver's wage	6.9	9.2%
Depreciation	4.7	6.3%
Cost of Capital	3.6	4.8%
Insurance	3.1	4.2%
Tyres	0.8	1.1%
Toll Fees	2.5	3.3%
Vehicle licences	0.4	0.5%
Rail charges	9.7	12.8%
Total	**75.4**	**100%**

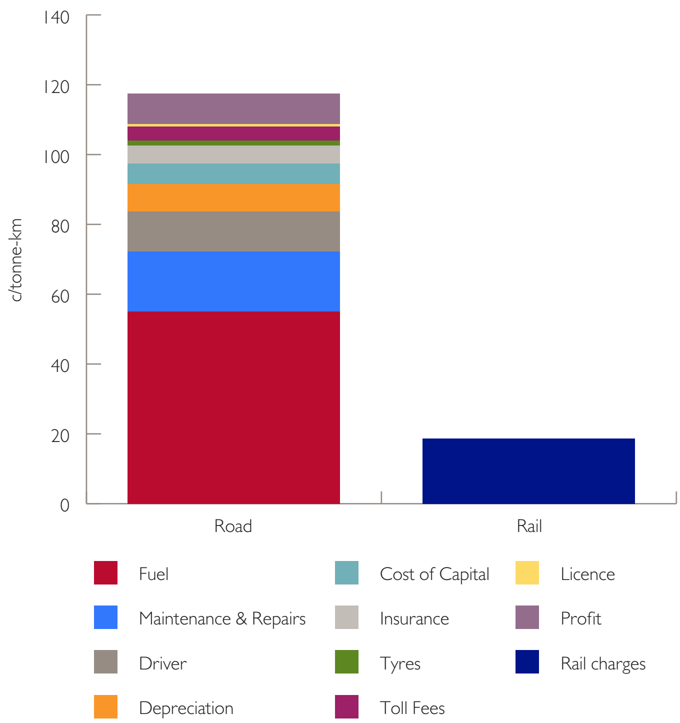


Figure 2: Transport cost in c/tonne-km per mode for Western Cape freight (2022)

Highlights

- In 2022, road freight transport accounted for 87% of the total transportation cost.
- The main road freight transport cost drivers were fuel (R33.3 billion; 44.2% of total cost), maintenance and repairs (R10.3 billion) and driver wages (R6.9 billion).
- Fuel cost increased by 50% against 2020 and 39.7% against 2021, driven by higher fuel prices.
- With its current low market share, the South African freight railway's challenge is that it needs a substantial modal shift from road to realise density benefit and further emphasises the significance of resolving the rail crisis in South Africa.

Externality cost

The total estimated CO_2 emissions for South Africa (2021) are 436 million tonnes[1], of which approximately 26 million tonnes are for freight. In order to have a holistic view of transportation cost, externalities such as emissions need to be taken into account. The externality components are the costs associated with accidents, congestion, emission, land use, noise and policing. These components are calculated as a relative cost per tonne-km per mode and can be applied to any subset of freight movements, such as the Western Cape. South Africa has an established national externality cost model[2] that can be used to estimate these costs. The rates are summarised in Table 1 and are the latest available 2017 values (no other recent available rates).

Table 1: National externality cost rates per component, 2017 (cent per tonne-km)

	Road	Rail
Accidents	4.79	0.41
Congestion	2.95	
Emissions	8.97	1.21
Landway	0.87	0.08
Noise	3.24	0.03
Policing	2.29	

Emissions costs include not only CO_2 gasses, but all emissions that are produced by burning fuel. The emissions produced per litre of burnt diesel are given in Table 2.

Considering the average fuel usage per tonne-km of all freight vehicles, the resultant emissions in grams per tonne-km are given in Table 3, which can be used to compare emissions per modes.

Table 2: Grams produced per litre and estimated costs, per component of emissions

Acronyms[3]	NO_x	PM metro	PM rural*	HC	CO	CO_2**	SO_2
Grams produced, per litre (g/l) of fuel burnt	26.5	1.19	1.19	0.70	4.00	2 688	12.56
Assumed cost per ton, based on international perceived values (Rand)	27 721	612 906	180 525	8 113	8 113	334	54 090

Table 3: Grams of emissions produced per mode per tonne-km

	NO_x	PM metro	PM rural*	HC	CO	CO_2**	SO_2
Road tonne-km	0.71	0.03	0.03	0.02	0.11	72.41	0.34
Rail tonne-km (electric)						28.34	
Rail tonne-km (diesel)	0.42	0.02	0.02	0.01	0.06	42.96	0.2
Rail tonne-km (weighted average of electric and diesel)	0.04	0.002	0.002	0.001	0.005	29.58	0.02

** While particulate matter (PM) is produced equally in metropolitan and rural areas per litre of fuel burnt, its perceived cost is higher in more densely populated areas*

*** To calculate the cost of CO_2 emissions for South Africa, a cost of R225 per tonne of CO_2 is assumed for 2010, in line with the proposals of the South African National Treasury (2010) and McCarl and Sands (2007)*

[1] https://ourworldindata.org/co2/country/south-africa#what-are-the-country-s-annual-co2-emissions

[2] For a detailed methodology of the externality costs model, refer:
Swarts, S., King, D., Simpson, Z., Havenga, J., and Goedhals-Gerber, L. (2012), 'Calculation of freight externality costs for South Africa, *Journal of Transport and Supply Chain Management*, Vol. 4 No. 1 and
Havenga, J.H. (2015), 'Macro-logistics and externality cost trends in South Africa – Underscoring the sustainability imperative', *International Journal of Logistics Research and Applications*, Vol. 18 No. 2, pp. 118–139, https://doi.org/10.1080/13675567.2015.1015509.

[3] Acronyms: **NOx** = Nitrogen oxides; **PM metro** = Particulate matter metro; **PM rural** = Particulate matter rural; **HC** = Hydro Carbons; **CO** = Carbon Monoxide; **CO_2** = Carbon dioxide; **SO_2** = Sulphur dioxide

Accidents cost more than the cost of damage to the involved vehicles, which is internalised through insurance policies. Apart from the direct cost of replacing or repairing a vehicle there are additional economic costs due to loss of life and productivity which can be quantified through value of statistical life tables. In South Africa the Road Accident Fund levy directly internalises some, but not all of this externality cost.

Noise externality cost is based on the willingness to pay to avoid the proximity of living near noisy road or rail infrastructure. A small percentage of national GDP is used based on international benchmarks to estimate the total willingness to pay for South Africa and is then disaggregated across road and rail.

Congestion is the increase in travel time road users experience due to travel demand exceeding road capacity constraints. Large trucks take up the equivalent of roughly 3.5 passenger car equivalents on the road. It is calculated by taking the difference between average vehicle speeds and expected free flow speed across counted sections where the number of vehicles per hour per lane exceeds the free flow limit. As all vehicles are traffic and contribute toward congestion, different vehicle types' contribution are normalised to passenger car equivalents. This gives a split of the total time lost due to congestion to each vehicle use (passenger and freight) which is monetarily quantified based on a cost per hour.

Policing externality cost is based on the national estimated budget per person spent on traffic policing. This cost is attributed to freight activity based on the live vehicle population composition.

Apart from the necessity of initially connecting different areas of the country, there is an external cost associated with the expanded land use of transport infrastructure that could have been used for other economic activities. Roads are expanded to alleviate congestion, rather than finding more space-efficient means of transportation. This cost is attributed to freight according to an estimate of annual distance travelled per vehicle type and the live vehicle population.

The resultant total externality costs for Western Cape freight are given in Figure 1 and Table 4. Rail externality costs are negligible relative to road externality costs.

The total externality costs for road freight transport in the Western Cape for 2022 amount to R13.97 billion, which is 21.3% of direct road freight transport costs[4] for the same period. Road freight transport contributes 94% of the total land freight transport externality costs[4] of R14.87 billion.

The four largest road freight transport externality cost drivers, namely, emissions, accidents, noise and congestion, contribute more than 80% to total freight transport externality costs in the province, impacting the general population while not being carried by the users of the service. When externality costs are not internalised, road freight operators are effectively cross subsidised by individuals living in polluted air (emissions) or next to noisy roads, or commuters travelling on congested routes. Furthermore, taxpayers fund the clearing of accidents and rehabilitation of damaged roads. The internalisation of externality costs can be induced through both "negative" and "positive" policy interventions. "Negative" policy instruments relate to measures such as congestion charges, emission taxes, noise controls, land use limitations and user-pay principles. "Positive" policy instruments relate to a regulatory framework supportive of the creation of industry associations, logistics hubs and public-private partnership models. This could encourage widespread modal shift to induce a systemic change by which most of rail-targetable freight is shifted to rail[4].

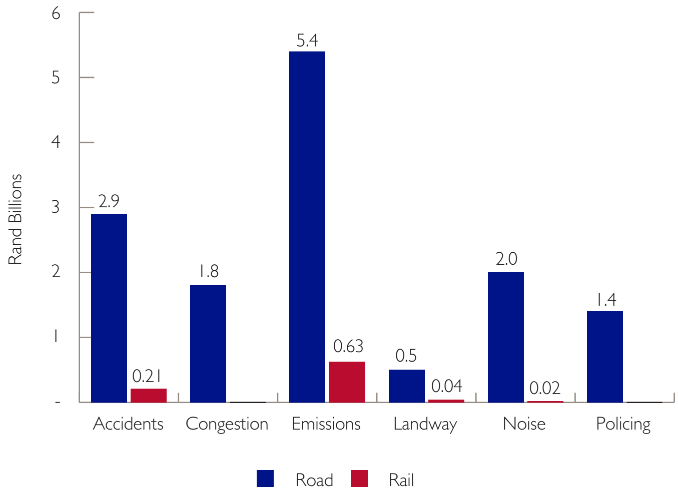


Figure 1: Externality costs for Western Cape freight (2022)

Externality cost driver	Road Cost Rbn (% of driver cost)	Rail Cost Rbn (% of driver cost)	Total Cost Rbn (% of total)
Emissions	5.42 (90%)	0.63 (10%)	6.05 (41%)
Accidents	2.89 (93%)	0.21 (7%)	3.11 (21%)
Noise	1.96 (99%)	0.02 (1%)	1.98 (13%)
Congestion	1.78 (100%)	-	1.78 (12%)
Policing	1.39 (100%)	-	1.39 (9%)
Landway	0.52 (93%)	0.04 (7%)	0.57 (4%)
Total	13.97 (94%)	0.90 (6%)	14.87 (0%)

Table 4: Externality costs for Western Cape freight (2022)

Highlights

- The total externality for road freight transport in the Western Cape amounts to R13.97 billion, which is 21.3% of current road freight transport costs.
- Road freight transport contributes 94% of the total freight transport externality cost of R14.87 billion.
- The four largest road freight transport externality cost drivers, namely emissions, accidents, noise, and congestion contribute more than 80% to total freight transport externality costs in the province, impacting the general population while not being carried by the users of the service.
- The internalisation of externality costs can be induced through policy interventions.
- Policy interventions could induce a systemic change to shift rail-targetable freight to rail.

[4] Total direct road cost for 2022 is R65.7bn. If the road externality cost of R13.97bn is internalised, the total road transport cost will increase by 21.3% to R79.7bn.

[5] Refer to Havenga, J.H. and Simpson, Z.P. (2016), 'Freight logistics' contribution to sustainability: Systemic measurement facilitates behavioural change', Transportation Research Part D: Transport and Environment, Vol. 58. pp. 320-331, https://doi.org/10.1016/j.trd.2016.08.035 for a case study on the internalisation of national externality costs.

Scenarios

The WC FDM™ enables the development of data-driven scenarios to inform inter alia industrial and freight transport policies, and spatial planning. Pressing policy issues were identified and high-level scenarios were developed to estimate the potential annual impact on freight transport costs and Gross Domestic Product (GDP) in the Western Cape. The current results are indicative, with the purpose of encouraging discussions to increase the accuracy of the scenario development inputs. Once agreement is reached on the high-level scope and outcomes of these scenarios, priorities will be set to guide the implementation process for these scenarios.

Modal shift scenarios

The modal shift scenario is for commodities that have been identified as rail friendly, based on the density attributed to the origin and/or destination, packaging type and distance. To calculate the potential opportunity cost, at current prices, of a shift of freight from road to rail, or a lack thereof, the following baseline scenarios are quantified:

1. **Stagnant rail volumes,** where rail's volumes remain the same over the forecast period;
2. **Constant rail market share**, where rail's percentage remains the same over the forecast period;
3. **Growth in rail market share** where rail's market share grows to capture all the rail-friendly traffic (i.e. able to be shifted to rail).

The impacts on transport costs and emissions are calculated for each of these baseline scenarios.[1] That is, what is the potential for modal shift, given each of the three baselines.

Assumptions

- Assuming 2022 average transport costs per segment, total transport costs were calculated for each scenario.
- In the absence of an average cost per segment, the overall average cost per mode was used.
- Modal shifts for forecast years are calculated at 2022 prices. This provides a conservative estimate – it has been shown that as rail freight density increases the mode becomes more efficient.
- Modal shift scenarios are developed for the Western Cape portion of each of the three (3) long-distance corridors traversing the Western Cape, namely the N1, N2 and N7, as well as for short-distance freight transported locally in the Core Western Cape region.

Results

The modal shift scenario results are depicted in Tables 2, 4, 6 and 8.

N1 corridor

The key opportunities for modal shift on the N1 corridor are in the siding-to-siding and palletised Fast-Moving Consumer Goods (FMCG) segments. The volumes that could be shifted are shown in Table 1 and depicted graphically in Figure 1.

[1] Where current rail rates are above road market rates it is assumed that freight switching to rail will do so at road market rates.

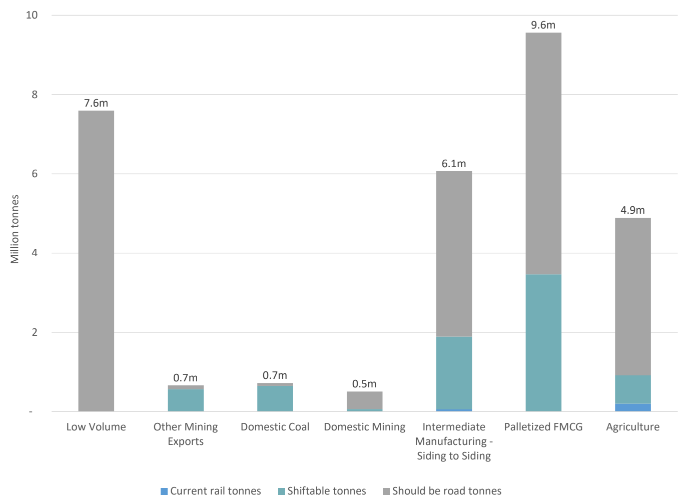


Figure 1: Modal shift opportunity per segment on the N1

Table 1: Modal shift opportunity per segment on the N1

Segment	Road tonnes	Rail tonnes	Shiftable tonnes
Low volume targetable	7 593 617	3 069	(0%)
Other mining exports	662 179	-	566 364 (85.5%)
Domestic coal	722 562	-	649 637 (89.9%)
Domestic mining	503 949	-	62 970 (12.5%)
Intermediate manufacturing - Siding to siding	6 012 481	55 736	1 836 493 (30.5%)
Palletised FMCG	9 562 852	-	3 461 730 (36.2%)
Agriculture	4 692 989	199 501	713 162 (15.2%)
Total	**29 750 629**	**258 307**	**7 290 35 (24.1%)**

Transport costs[2] on the N1 corridor for these segments are currently 17.4% higher, compared to costs under a scenario in which all shiftable freight was transported by rail (see Table 2). If rail volumes remain stagnant up to 2053 this premium will be 16.3%. If the rail market share remains constant up to 2053 this premium will be 16.1%.

Table 2: Cost and emission savings potential due to modal shift on the Western Cape section of the N1

Scenarios	Transportation cost before shift (Rbn)	% Transport cost premium with no modal shift	Shift Saving (Rbn)	CO_2 emission reduction (000' tonnes)
2022 - Current market share	42.9	17.4%	6.35	385.4
2028 - Stagnant rail volumes	48.5	17.1%	7.09	436.6
2028 - Constant market share	48.5	17.1%	7.07	434.6
2028 - Growth market share	41.1	-	-	-
2053 - Stagnant rail volumes	91.1	16.3%	12.78	811.7
2053 - Constant market share	90.9	16.1%	12.58	798.8
2053 - Growth market share	77.7	-	-	-

[2] These transport costs are road and rail costs for the identified rail friendly segments.

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N2 corridor

The key opportunities for modal shift on the N2 corridor are in the siding-to-siding, palletised FMCG and agriculture segments. The volumes that could be shifted are shown in Table 3 and depicted graphically in Figure 2.

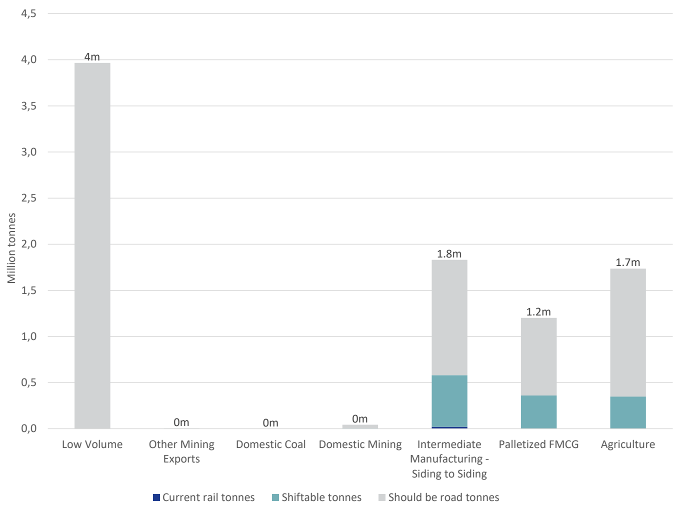


Figure 2: Modal shift opportunity per segment on the N2

Table 3: Modal shift opportunity per segment on the N2

Segment	Road tonnes	Rail tonnes	Shiftable tonnes
Low volume targetable	3 966 041	-	(0%)
Other mining exports	3 366	-	2 879 (85.5%)
Domestic coal	-	-	(0%)
Domestic mining	42 988	-	5 371 (12.5%)
Intermediate manufacturing - Siding to siding	1 809 232	21 398	559 952 (30.9%)
Palletised FMCG	1 200 856	1 009	359 273 (29.9%)
Agriculture	1 735 770	-	348 817 (20.1%)
Total	**8 758 252**	**22 407**	**1 276 292 (14.6%)**

Transport costs on the N2 corridor across all segments are currently 3.9% higher than they would be if all shiftable tonnes were transported by rail (see Table 4). If rail volumes remain stagnant this will be 3.5% by 2053.

Table 4: Cost and emission savings potential due to modal shift on the Western Cape section of the N2

Scenarios	Transportation cost before shift (Rbn)	% Transport cost premium with no modal shift	Shift Saving (Rbn)	CO_2 emission reduction (000' tonnes)
2022 - Current market share	5.8	3.9%	0.22	31.6
2028 - Stagnant rail volumes	6.3	3.7%	0.22	33.6
2028 - Constant market share	6.3	3.7%	0.22	33.7
2028 - Growth market share	6.0	-	-	-
2053 - Stagnant rail volumes	11.4	3.5%	0.38	61.9
2053 - Constant market share	11.4	3.5%	0.38	61.8
2053 - Growth market share	11.0	-	-	-

N7 corridor

The key opportunity for modal shift on the N7 corridor is in agri- culture, and to a lesser extent siding-to-siding freight. The volumes that could be shifted are shown in Table 5 and depicted graphically in Figure 3.

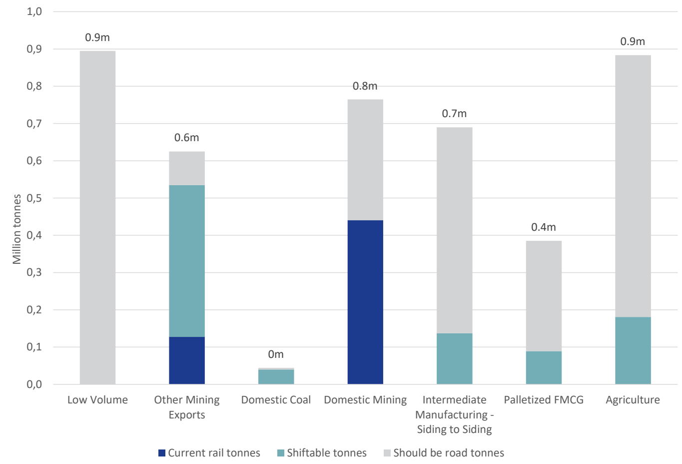


Figure 3: Modal shift opportunity per segment on the N7

Table 5: Modal shift opportunity per segment on the N7

Segment	Road tonnes	Rail tonnes	Shiftable tonnes
Low volume targetable	894 329	-	(0%)
Other mining exports	497 672	127 351	407 233 (81.8%)
Domestic coal	44 207	-	39 745 (89.9%)
Domestic mining	324 437	440 209	(0%)
Intermediate manufacturing - Siding to siding	689 915	-	137 165 (19.9%)
Palletised FMCG	385 130	-	89 100 (23.1%)
Agriculture	882 994	-	180 282 (20.4%)
Total	**3 718 684**	**568 528**	**853 524 (23.0%)**

Transport costs on the N7 corridor are currently 18.8% higher than they would be if all shiftable tonnes were transported by rail (see Table 6). If rail volumes remain stagnant this will increase to 22.4%, by 2053. If the rail market share remains constant this will be to 11.7%.

Table 6: Cost and emission savings potential due to modal shift on the Western Cape section of the N7

Scenarios	Transportation cost before shift (Rbn)	% Transport cost premium with no modal shift	Shift Saving (Rbn)	CO_2 emission reduction (000' tonnes)
2022 - Current market share	2.0	18.8%	0.32	11.1
2028 - Stagnant rail volumes	2.3	15.2%	0.30	12.7
2028 - Constant market share	2.3	13.7%	0.27	11.9
2028 - Growth market share	1.9	-	-	-
2053 - Stagnant rail volumes	4.9	22.4%	0.90	32.6
2053 - Constant market share	4.5	11.7%	0.47	21.5
2053 - Growth market share	3.8	-	-	-

Western Cape core traffic

The key opportunity for modal shift in the Western Cape core traffic is in agriculture, and to a lesser extent domestic coal and siding-to-siding traffic. The volumes that could be shifted are shown in Table 7 and depicted graphically in Figure 4. Due to the low freight transport distances and density outside metro areas, road is currently more competitive for certain commodities than rail in segments such as agriculture and intermediate manufacturing.

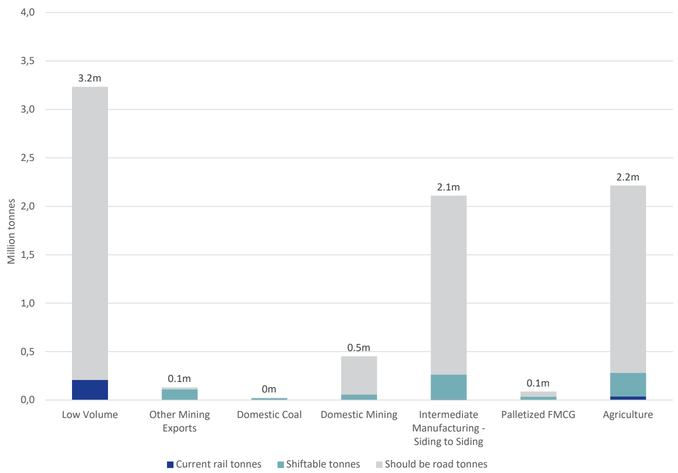


Figure 4: Modal shift opportunity per segment for Western Cape core traffic

Transport costs for the Core Western Cape across all segments are currently 2.6% higher in the absence of modal shift (see Table 8). By 2053 if rail market share remains stagnant this is will be 1.9%, given that rail rates remain relatively high. This is due to the growth in the freight flows in which road is more competitive.

Table 8: Cost and emission savings potential due to modal shift on the Western Cape core traffic

Scenarios	Transportation cost before shift (Rbn)	% Transport cost premium with no modal shift	Shift Saving (Rbn)	CO_2 emission reduction (000' tonnes)
2022 - Current market share	0.88	2.6%	0.02	2.77
2028 - Stagnant rail volumes	0.99	2.2%	0.02	2.98
2028 - Constant market share	0.99	2.2%	0.02	2.96
2028 - Growth market share	0.97	-	-	-
2053 - Stagnant rail volumes	1.94	1.9%	0.04	5.72
2053 - Constant market share	1.93	1.9%	0.04	5.59
2053 - Growth market share	1.89	-	-	-

Summary

In 2022 the total transportation bill for freight touching the Western Cape was R75.4bn. The combined effect of the modal shift on the three corridors and core Western Cape traffic would have been a reduction of R6.91 billion or 9.2% in transport costs for the Western Cape (the 2022 market share data in the tables above)[3].

[3] These results refer to the transport cost saving. Additional investments can be included in a high-level business case.

Table 9: Summary - cost and emission savings potential due to modal shift in the Western Cape

Freight traffic zone	Shift saving 2022 (Rbn)	% saving on total Western Cape transport bill	CO_2 emission reduction (000' tonnes)
N1	6.35	8.42%	385.4
N2	0.22	0.29%	31.6
N7	0.32	0.42%	11.1
Core Western Cape	0.02	0.03%	2.77
Total	**6.91**	**9.16%**	**430.9**

Table 10 shows the targetable modal shift opportunities across all Zonal groupings. Just as the cost savings suggest, the N1 has the largest potential for modal shift. Of the 86.5m tonnes of Western Cape Road freight, a portion of 41.8m tonnes are suitable for a shift to rail. The non-suitable road freight consists of low density freight flows, fuel and commodities which have a dedicated rail solution, like the iron ore export line.

Table 10: High level estimate of total shiftable tonnes per Zonal grouping of Western Cape Freight.

Zonal Grouping	Road tonnes (million)	Rail tonnes (million)	Total tonnes (million)	Shiftable tonnes (million)	Shiftable tonne-kms (billion)	Estimated Transportation Cost Saving (R billions)
N1 Corridor traffic	22.2	0.3	22.4	7.3 (32.5%)	10.5	6.35
N2 Corridor traffic	4.8	0.0	4.8	1.3 (26.5%)	0.9	0.22
N7 Corridor traffic	2.8	0.6	3.4	0.9 (25.2%)	0.3	0.32
Metropolitan traffic	2.9	-	2.9	0.2 (8.2%)	0.01	0.019
Core Western Cape	5.0	0.0	5.0	0.7 (14.5%)	0.1	0.022
Non-Corridor traffic	4.2	0.0	4.2	1.3 (31.1%)	1.8	1.12
Total	**41.8**	**0.9**	**42.7**	**11.7 (27.4%)**	**13.5**	**8.05**

Highlights

- As rail traffic becomes more dense, it becomes more efficient.
- An estimated 9.2% of the Western Cape's total freight transportation cost could have been saved in 2022 through modal shift.
- Increased potential for modal shift cost savings (when compared to the 2021 results) was driven primarily by the increase in the higher fuel price in 2022.
- At current rail volumes, road is more competitive within the Core Western Cape area.
- The largest modal shift opportunity is for the N1 corridor freight. This could potentially save 8.42% of total transport cost.

Introduction

The WC FDM™ enables the development of data-driven scenarios to inform inter alia industrial and freight transport policies, and spatial planning. Pressing policy issues were identified and high-level scenarios were developed to estimate the potential annual impact on freight transport costs and Gross Domestic Product (GDP) in the Western Cape. The current results are indicative, with the purpose of encouraging discussions to increase the accuracy of the scenario development inputs. Once agreement is reached on the high-level scope and outcomes of these scenarios, priorities will be set to guide the implementation process for these scenarios.

The National Infrastructure Plan 2050 (NIP 2050)[1] emphasises that Transport policy must align with supply chain requirements and encourage the development of transport hubs to foster industrial diversification and clustering. It further states that South Africa needs to integrate rail, road, ports, intermodal hubs, and freight villages (also referred as a super hubs or terminals)

Terminal options

Freight logistics hubs serve as important consolidation points where the value in logistics is added to the movement of containers and bulk or break-bulk freight. These hubs can become integrated inland intermodal facilities as consolidation points between modes, enabling the transition between road and rail (subject to a functional rail system). Terminals can have many forms as depicted in Table 1.

Table 1: Terminal options

Facility description	Use
Rail siding or depot	Dedicated to a single user
Dedicated comodity terminal	Single focus transshipment
Multi-purpose terminal (MPT)	Multi-purpose transshipment
Logistics park	MPTs and warehouse combination
Logistics service centre	Logistics parks providing ancillary logistics services
Freight village	Logistics service centres with light manufacturing

Various development possibilities around these options exist and at least one Freight Village (Super terminal) for the Western Cape is required. As the terminals become increasingly integrated, they provide not only consolidation platforms but also service centres and logistics planning platforms for the province as a whole. A Freight Village that also includes light manufacturing shortens links in supply chains, making these more efficient and relative infrastructure use and externalities less for the same unit of output. It could link all rail sidings, dedicated commodity terminals, multi-purpose terminals and ports in the province in an integrated whole.

[1] The National Infrastructure Plan 2050, 2022, https://www.gov.za/sites/default/files/gcis_document/202203/46033gon1874.pdf

Western Cape Terminal network

In this scenario a terminal network for the Western Cape was considered, comprising of a central super terminal or freight village, port connectivity, and network of handling points for containers, fruit, processed food, and fuel, as shown in Figure 1.

Super terminal: Also referred to as a freight village or super hubs is a specialised area designed to facilitate various aspects of freight transportation, logistics, and distribution activities. It's a strategic hub that not only integrates various logistics functions and services to streamline the movement and storage of goods, but also enable light manufacturing around basic food processing, packaging, product assembly and beneficiation.

Port: serve as convergence points where land-based and maritime freight intersect. It refers to the latin word "portus" that means gate or gateway[2].

Terminal: refer to a central point or location where freight either originates, terminates, is consolidated or is handled in the transport of freight. Terminals can specialise in specific commodities or packaging types, for example, containers, fruit, processed food, fuel.

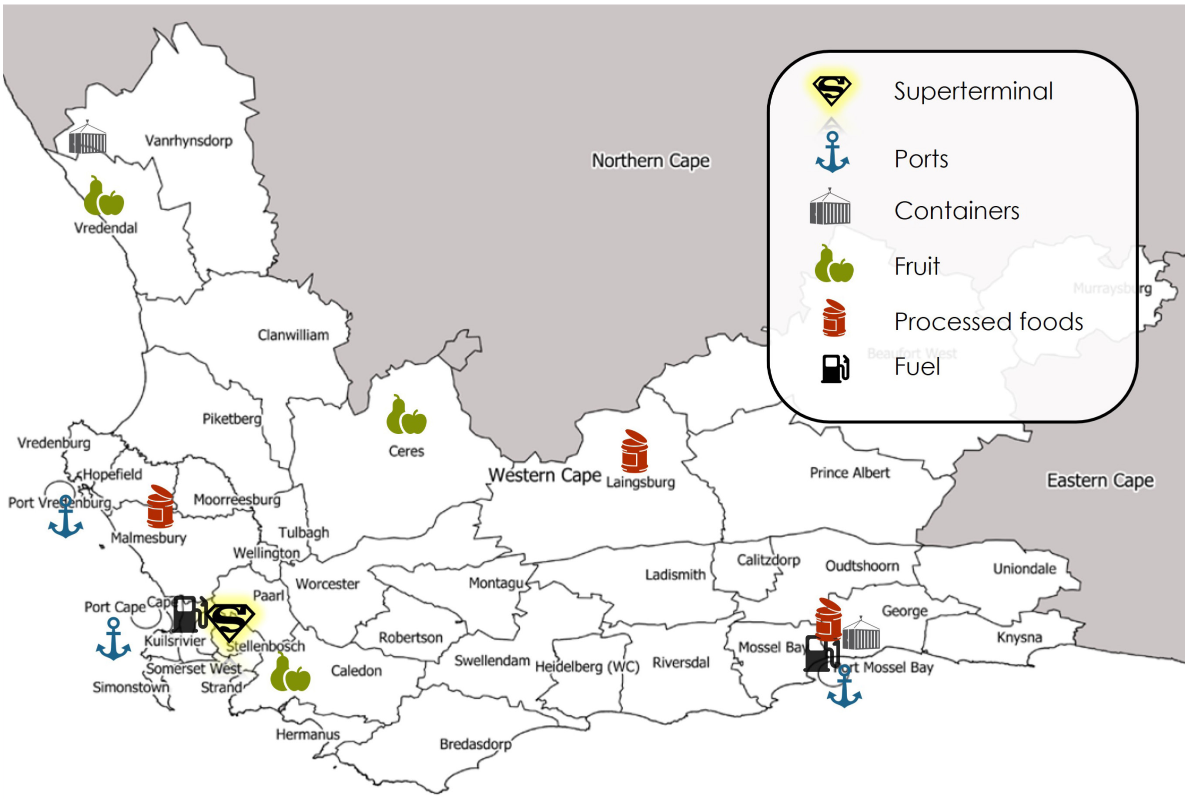
Scenario assumptions

Overall: A functional rail system.

Fruit terminals: The volume target is the full export volumes (due to being dedicated to those specific fruit exports).

Other terminals: The volumes target is natural modal shift volumes suitable to rail, plus an additional 50% of the remaining road volumes (due to the assumed positive effect of such terminal).

[2] Rodrigue, JP, Comtois, C. & Slack, B. 2017. The Geography of Transport Systems, 4th edition. New York: Routledge.



The super terminal targets palletised freight between Western Cape, and either Gauteng, Limpopo, Mpumalanga and Durban surrounds (excluding the volumes of the two smaller container terminals identified). The Kraaicon terminal was identified by pre-feasibility studies by Transnet and the City Of Cape Town. This terminal could have an annual handling potential of over 4 million tonnes, and alleviate a significant volume of trucks off the roads by utilising rail connections to and from the super terminal. This proposed network design could potentially save R1 650.1m and R1 638.8m, of transportation and externality costs, respectively.

The two smaller container terminals identified, target palletised freight between the Garden Route and Gauteng, or the Garden Route and the City Cape Town as well as any cargo type of freight, between City of Cape Town and Namibia or Namaqualand. These terminals are at George and on the Bitterfontein rail line (north of Vredendal) and have the potential to handle approximately 170 thousand tonnes each annually. The proposed George container terminal could potentially save R16.7m and R35.1m, of transportation and externality costs, respectively. However, the Bitterfontein terminal is estimated to result in a transportation cost increase of R21.2m and an externality cost saving of only R4.3m, despite making use of the super terminal.

Fruit terminals target all export fruit and the identified three potential fruit terminal locations based on the cluster of fruit volumes in the region are Ceres, Caledon and Vredendal. These terminals each have the potential to handle approximately 260 thousand tonnes annually. This proposed network design could potentially save R32.3m and R22.8m, of transportation and externality costs, respectively.

Processed food terminals identified are at Malmesbury, George and Laingsburg. These terminals target palletised food and beverages between their immediate surroundings and either Gauteng, Limpopo, Mpumalanga and Durban surrounds. The Malmesbury terminal should have an annual potential of 400 thousand tonnes, with the George and Lainsburg terminals having annual potential of 240 thousand tonnes and 100 thousand tonnes respectively. This proposed network design could potentially save R311.9m and R261.2m, of transportation and externality costs, respectively.

The fuel terminals identified are situated at Mosselbay and Cape Town area. There is a need for an integrated strategy for fuel flows between the City of Cape Town and Mossel Bay. To execute this integrated strategy effectively, it's essential to involve all stakeholders participating in the Western Cape fuel supply chain. This includes the Central Energy Fund, PetroSA, Transnet, Transnet National Port Authority, Civil Aviation Authority, Western Cape provincial government, and local municipalities.

An integrated strategy for the Western Cape's ports—Cape Town, Saldanha, and Mossel Bay—promises multiple advantages. By aligning activities and resources, these ports can significantly improve overall efficiency, optimising resource allocation, refining processes, and managing traffic more effectively. This approach could also elevate shipping interest and investment, ultimately strengthening the province's economic prospects. Together, these ports can gain a competitive edge in global trade by presenting more attractive and efficient logistics solutions to shipping companies. A crucial aspect of this strategy involves focusing on specialised opportunities tailored to the strengths of each port, aligning with the integrated terminal approach. Available capacity can also be exploited more efficiently from a combined back of port or dry port facility, that services all three ports in the Western Cape.

Conclusion

The estimated cost savings for the proposed terminal network is R1.99bn on transport cost and R1.97bn on externality cost. A well-planned and executed terminal network significantly boosts the efficiency, cost-effectiveness, and overall competitiveness of South African supply chains. To support this, the provincial government's role is pivotal. Creating supportive regulatory frameworks aligned with national policies and fostering collaborative partnerships with businesses and stakeholders in the logistics and supply chain industry are key steps. Through proactive engagement, the provincial government can optimise supply chains, drive economic growth, and enhance the province's competitiveness. The value of this network extends beyond individual facilities; it lies in the collaborative interactions and shared benefits among interconnected connections. This interconnectedness cultivates resilience, innovation, efficiency, and growth within the supply chain ecosystem.

Highlights

Potential Western Cape terminal network:

Terminal type	Location	Annual potential volume (tonnes)	Transport cost saving (Rm)	Externality cost saving (Rm)
Super terminal	Kraaicon	4 000 000	1 650.1	1 638.8
Container terminal	George	170 000	16.7	35.1
	Bitterfontein	170 000	(21.2)	4.3
Fruit terminal	Ceres	260 000	1.0	7.0
	Caledon	260 000	5.8	6.8
	Vredendal	260 000	25.5	9.0
Processed food terminals	Malmesbury	400 000	196.6	142.5
	George	240 000	57.3	79.2
	Lainsburg	100 000	58.0	39.5

An integrated strategy for the Western Cape's ports - Cape Town, Saldanha, and Mossel Bay should be developed.

GAIN GROUP Insight drives growth

Introduction

The WC FDM™ freight flows are derived from economic activity, specifically activities that contribute to transportable GDP, which consists of the extraction of raw materials and manufacturing (also known as the primary and secondary economic sectors respectively). Although waste does not contribute to the GDP directly, it has an indirect impact since its transportation and disposal requires resources that could have been used for activities that contribute to the GDP.

The WC FDM™ waste forecast investigates a plausible relationship between waste generation and commodity demand. Waste Management and the logistics behind it is itself a complicated subject. Waste generation is inherent not only to the consumption of goods but also to extraction and manufacturing processes. Therefore, a portion of transportable GDP will end up in landfill. The amount of waste generated per type of product can also vary depending on the packaging type. For instance, wrapping four apples with plastic mesh on a paper container (which is covered with another layer of plastic) as opposed to 1.5 kg apples in a plastic bag.

The third goal of the Western Cape Integrated Waste Management Plan (IWMP) 2022 – 2027 is the effective and efficient utilisation of resources, which has the following objectives: Minimise the consumption of natural resources and promote the circular economy; stimulate job creation within the waste economy; and increase waste diversion through reuse, recovery, and recycling. The private sector, both locally and internationally, has also seen opportunities to reduce its waste footprint with zero-waste stores where consumers bring their own containers when purchasing goods. Waste generation is, therefore, a changing landscape depending on the manufacturer of final goods and consumer behaviour, both of which can be influenced by the local and provincial government.

When goods are not reused or recycled, it eventually ends up in a landfill or polluting the environment. Knowing the lifespan of a landfill site is integral to any integrated waste management planning. Forecasting waste volumes is therefore an important but difficult task and what proves sufficient for one waste stream will not be for another. The difficulty of waste forecasting can be seen in a study of municipal waste generation in the City of Logan in Australia. The study used different Artificial Intelligence methodologies rather than previously used methodologies such as descriptive statistics, regression analysis, material flow modelling or time series analysis (Abbasi & Hanandeh, 2016). Their model accurately forecasted waste generation from 2012 to 2014 based on training data from 1996 to 2012. The study predicted that by 2020 Logan City will be generating 94 000 tonnes of Municipal Solid Waste. In reality, in the year 2020/21 the City of Logan generated 132 780 tonnes of municipal solid waste of which 48 289 tonnes was diverted.

Waste Overview

For the WC FDM™ waste forecast the following data inputs were used:

- City of Cape Town waste data from 2010 to 2022,
- WC FDM™ 2017 – 2022,
- National Freight Demand Model (FDM™) 2014 – 2016, and
- P3041.2 - Manufacturing: Production and sales - Statistics South Africa[1]

Reliable provincial waste data was not available before 2017 and was, therefore, left out of the analysis. Waste generation data was compared to WC FDM™ and national FDM™ demand data for the City of Cape Town (CoCT) to establish a link between freight demand and waste generation. The P3041.2 indices were used to extrapolate the demand for 2010 – 2013 from the FDMTM data.

The data processing methodology for the three WC FDM™ waste streams for the CoCT is discussed below. Apart from the 6 major facilities in the CoCT, there are 24 other municipalities within the Western Cape that are served by 113 waste facilities, (as can be seen in Figure 1), that report handling waste of which municipal, garden, organic (now included in the 2022 WCFDM) and construction and demolition make up the majority. The forecast that was used for the CoCT municipal waste assignments was also applied to WC FDM™ districts. Of the 174 977 tonnes of organic waste reported in the Western Cape as GW20, only 818 tonnes were generated within the City of Cape Town. Therefore, the organic waste forecast uses the same growth factors as the garden waste forecast on the assumption that fertilizer has the same link to organic waste generation as garden waste.

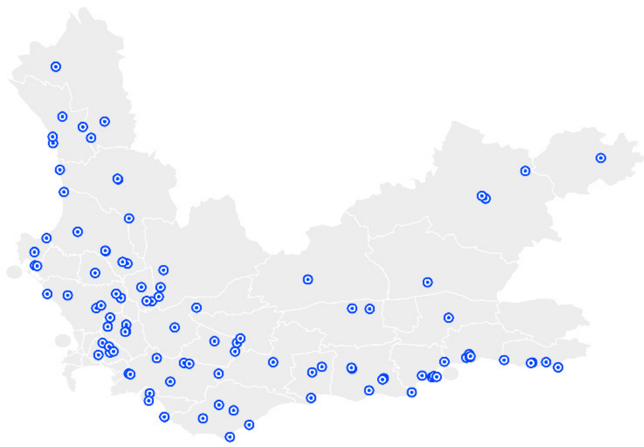


Figure 1: Waste facilities

[1] This statistical release contains information regarding indices of the physical volume of manufacturing production and the total value of sales of manufactured products, according to manufacturing divisions on a monthly basis. https://www.statssa.gov.za/?page_id=1861&PPN=P3041.2&SCH=73155

Abbasi, M. & Hanandeh, A.E. 2016. Forecasting municipal solid waste generation using artificial intelligence modelling approaches. Waste Management, 56:13-22, https://doi.org/10.1016/j.wasman.2016.05.018

1. GW01 – Municipal waste

Figure 2 shows the major catchment areas for each waste facility within the CoCT Municipality, with Figure 3 illustrating the waste collection and transfer process.

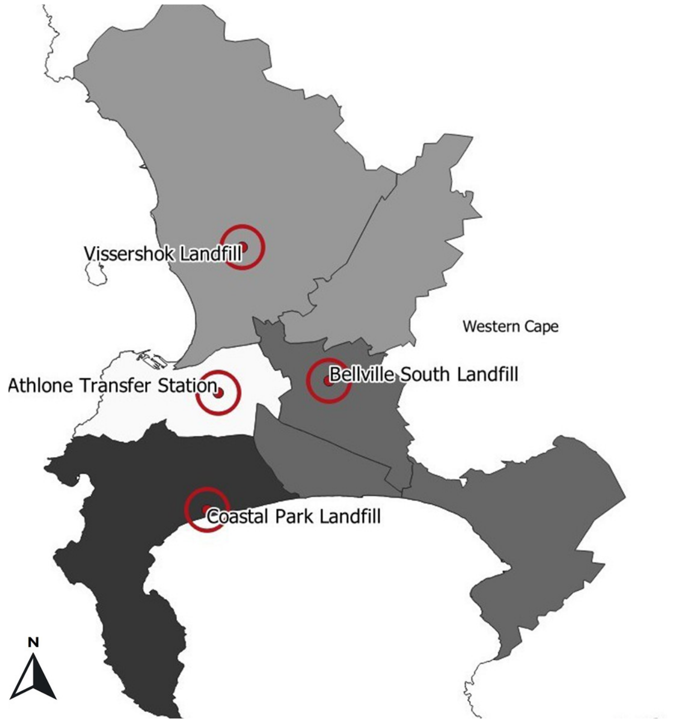


Figure 2: Catchment areas for the various refuse transfer stations and landfills in the CoCT Municipality.

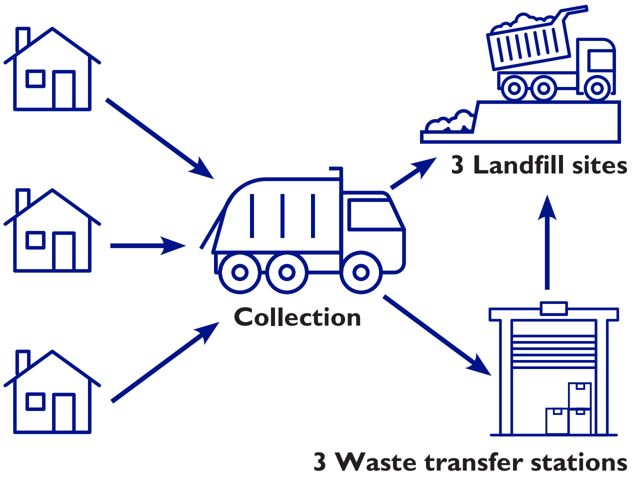


Figure 3: The waste collection and transfer process

Waste is not always taken directly to a landfill. There are three refuse transfer stations where waste gets dropped off and consolidated before being transported to one of the landfills.

For the WC FDM™, waste OD flows were generated based on the intersection of each WC FDM™ district with each of the municipal waste facilities catchment area. For districts that fall into multiple catchment areas, the waste flows were split between the different waste facilities.

It was assumed that municipal waste can be linked to the demand for processed foods and beverages. Unsurprisingly the demand for processed foods and beverages in the CoCT Municipality has grown since 2010. This contrasts with municipal waste generation, which has been on a slight decline since 2010 as can be seen in Figure 4.

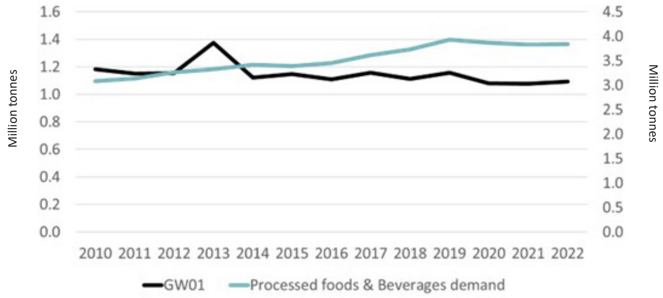


Figure 4: Municipal waste generation (left axis) and demand for processed foods and beverages (right axis) in CoCT Municipality 2010-2022.

Processed foods and beverages forecasts in the WC FDM™ take population growth into account and therefore population was not explicitly used as a means of the forecast, but it is indirectly accounted for.

For processed foods and beverages, if all the packaging is recycled and there is no wastage of the contents, then there is no waste generation. Conversely, if none of the packaging is recycled and all the contents go to waste, all demand for processed foods and beverages turns into waste. The amount of waste generation per tonne of processed foods and beverages per consumption is therefore subject to consumer behaviour regarding food waste and recycling. This behaviour is in turn shaped by initiatives like the Think Twice initiative pilot[2], which encouraged the separation of recyclable waste, and the Food Forward project[3] that encouraged the reduction of food waste.

It is, therefore, assumed that there is a constant relationship between the amount of packaging required for processed foods and beverages. However, it appears that waste reduction initiatives have been shaping consumer behaviour which led to a reduction of the municipal waste generation between 2010 and 2019, 'decoupling' demand for processed foods and beverages and municipal waste generation.

This reduction seems to halt in 2020 when it appears that waste generation and the demand for processed foods have coupled again, meaning that the waste generation increases faster than the waste reduction. This offset was calculated by comparing the waste generation to the demand for processed foods and beverages in 2010 and applying this ratio to the 2019 demand for processed foods and beverages. The difference between this 2010 generation rate applied the 2019 demand for processed foods and beverages and the actual generated municipal waste gives an indication of how much waste generation has been offset per year. It is estimated that between 2010 and 2021, waste reduction measures lead to cumulative decrease in the municipal waste generation of 34 000 tonnes per year. This means that each year there was an estimated municipal waste generation reduction of 34 000 tonnes as consumers and manufacturers adjust their habits and processes.

[2] Western Cape Government. 2007. *Think Twice - The City's Environmental Initiative: Waste Separation at Source - Launched in Pinelands and Parts of Blaauwberg* [Online]. Available: https://www.westerncape.gov.za/news/think-twice-citys- environmental-initiative-waste-separation-source-launched-pinelands-and-parts [2022, November 18].

[3] Western Cape Government. 2022. *Food Forward Project* [Online]. Available: https://www.westerncape.gov.za/110green/projects/food-forward-project [2022, November 18].

This reduction implies that a new baseline of waste generation is established, and that additional manufacturers and consumers further reduce their waste generation in the following year as can be seen in Figure 5.

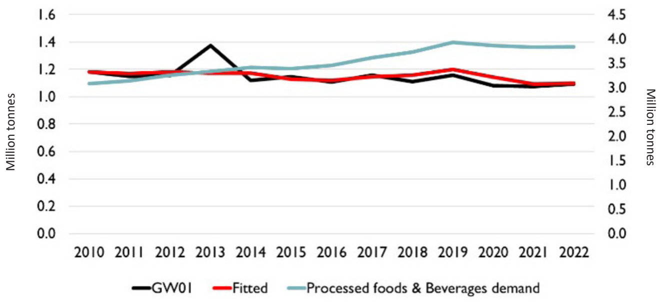


Figure 5: Municipal waste generation and estimated waste generation assuming an accumulating 34 000 tonnes per year offset, ending in 2021 (left axis) and demand for processed foods and beverages (right axis) in CoCT Municipality 2010-2022.

For the waste forecast, it was assumed that the cumulative offset was still present in 2022 after which the proportion of waste to processed foods and beverages remains fixed at 27.7% for future years which leads to the municipal waste forecast for the CoCT as can be seen in Figure 6.

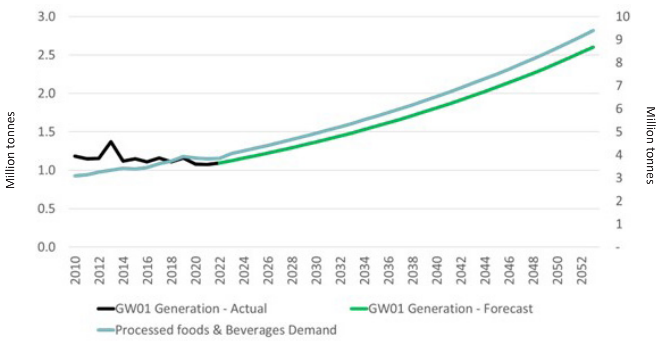


Figure 6: Processed foods and beverages demand for the CoCT and GW01 waste generation forecast.

Even though there is a definite disconnect between urban and rural municipal waste generation, the CoCT municipal forecast of 27.7% of processed foods and beverages is used to grow the 2022 municipal waste flows in the WC FDM™, as can be seen in Table 1.

Table 1: Municipal waste forecast for the Western Cape (million tonnes).

Origin	Actual	Forecast		
	2022	2023	2028	2053
CoCT	1.09	1.11	1.29	2.60
Rest of Province	0.41	0.42	0.51	1.02
Total	**1.51**	**1.53**	**1.80**	**3.62**

Given that there is no additional reduction at source or recycling uptake by consumers, municipal waste is forecast to increase 2.38 times by 2053, based on the forecast processed foods and beverage demand of the Western Cape.

2. GW20 – Organic waste

There are various flows of organic waste (GW20). This waste has the same catchment as municipal waste. Some of it ends up in landfills (this is already included in municipal waste, sometimes separated as GW20.02 "food waste"). And GW20.01 (garden waste) that is separated at source (e.g. by being dropped off at drop- off points). Some of this garden waste is then composted by private companies and sold as compost material. Reliance Compost (Pty) Ltd is the principal composting company, and transports all the garden waste to its composting site just outside Paarl.

Demand for fertilizer was the most likely commodity which could be linked to the generation of garden waste within the CoCT Municipality. It should be noted that there would be a definite disconnect between the demand for fertilizer in the CoCT and the rest of the province where fertilizer is used primarily for agricultural purposes concerning garden waste generation. However, because organic waste is included in the 2022 WC FDM, It is assumed that the relationship between garden and organic waste generation and fertilizer is similar enough, in the absence of a similar length time series for provincial municipal data on organic waste generation.

Figure 7 shows the waste generation of GW20.01 as well as the demand for fertilizer in the CoCT from 2010 to 2021. It is assumed that the steady decrease in garden waste generation was caused partly by the drought that started in 2015 and continued until 2018. The increase in garden waste generation in 2021 could possibly be explained due to the drop in 2020 caused by the COVID lockdown measures – a combination of lack of access to garden services and possibly shifting priorities during 2020 saw a decrease in trees being trimmed and gardens being maintained.

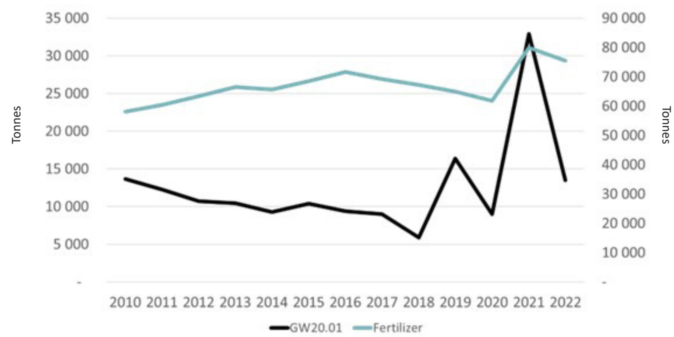


Figure 7: Garden waste generation (left axis) and fertilizer demand (right axis) for the CoCT.

As lockdown restrictions were eased, garden maintenance once again resumed which led to the increase or 'over recovery' in garden waste generation. It was expected that this steep trend would not continue past 2021, which seemed to be the case, given the 2022 data.

To forecast the garden waste a simple linear regression was used with GW20.01 = 0+X*(fertilizer demand) + ε. The output of the regression was that for every tonne of fertilizer demanded 190kg of garden waste is generated. The model had an R^2 of 0.82 with a p-value of (0.000007) which indicates that there is statistical plausibility between the demand for fertilizer and the generation of garden waste for the period 2010-2022. The estimated garden waste generation can be seen in Figure 8.

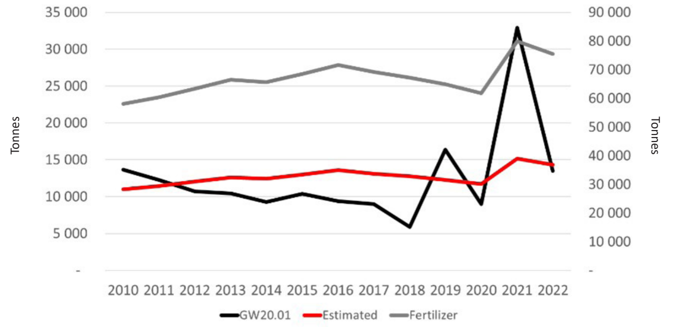


Figure 8: Garden waste generation and estimated waste generation (left axis) and fertilizer demand (right axis) for the CoCT.

Due to the nature of how garden waste is generated and its durability, another avenue of analysis would be to consider a simplified material flow approach as it shares a lot of similarities with construction and demolition waste (It is also stockpiled and partially reused). This is done by comparing the cumulative amount of garden waste generated to the cumulative demand for fertilizer from 2010 to 2022. That is the sum of garden waste divided by the sum of fertilizer demand for the CoCT, which comes to 187 kg of garden waste generation per tonne of fertilizer demand. This highlights the plausibility of using a simplified material flow approach for forecasting durable waste such as garden waste as well as construction and demolition waste. However, due to its statistical significance, the 190 kg was used for the forecasting of provincial garden waste as can be seen in Figure 9.

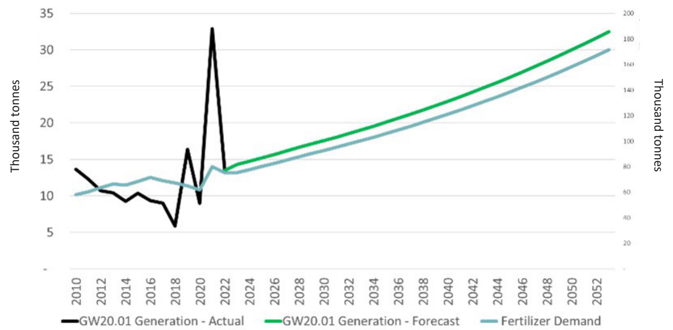


Figure 9: Fertilizer demand for the CoCT and GW20.01 waste generation forecast.

Garden waste was forecast on the same principle as municipal waste: The rate of change between 2022 and 2023, 2028 and 2053 based on the forecast of fertilizer demand was applied to all garden waste generation within the province as can be seen in Table 2.

Table 2: Forecast garden waste generation for the Western Cape (million tonnes)

Origin	Actual	Forecast		
	2022	2023	2028	2053
CoCT	0.01	0.01	0.01	0.03
Rest of Province	0.03	0.03	0.04	0.07
Total	**0.04**	**0.04**	**0.05**	**0.10**

Based on the forecast demand for fertilizer the total amount of garden waste generation is set to double by 2053.

3. GW30 – Construction and demolition waste

Figure 10 shows the movement of construction and demolition waste. Residents, as well as companies, can drop off small quantities of builders' rubble at one of the city's drop-off sites. There are 37 drop-off sites in Cape Town for this type of waste. From these sites, the waste is primarily taken directly to landfill. The catchment areas for construction and demolition waste are shown in Figure 11.

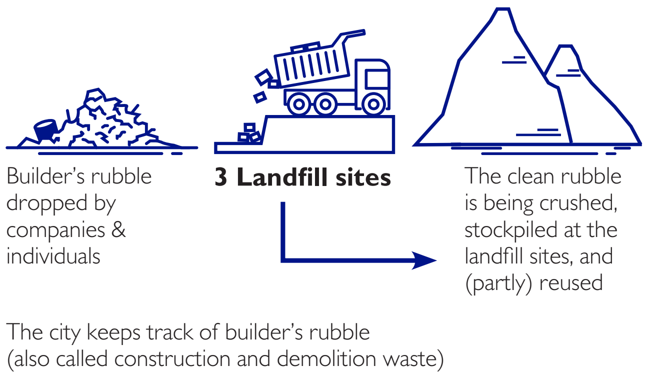


Figure 10: GW30 – Construction and demolition waste.

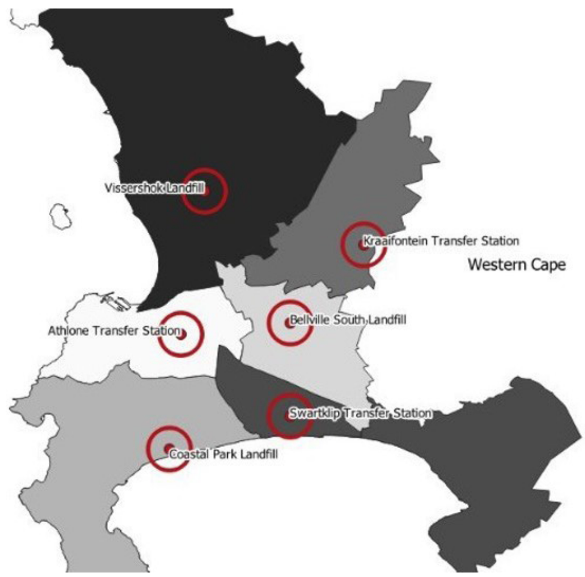


Figure 11: Catchment areas of industrial builder's rubble flow dropped off directly at landfill sites. This can come from anywhere in Cape Town, and it could go to any of the three landfill sites where it is stockpiled.

When considered in the context of the waste streams discussed up until now, construction and demolition waste is the most durable. All infrastructure and buildings are potential future sources of construction and demolition waste. Similar to how garden waste generation is dependent on the number of trees grown and eventually cut down or trimmed; construction and demolition waste generation is dependent on infrastructure, housing, or commercial construction projects. Therefore, it was assumed that the long-term generation of construction and demolition waste could be explained by the demand for bricks and cement. As infrastructure is expanded and new buildings are constructed, the raw material stocks are moved from the respective sources to waste facility stockpiles for future re-use. Figure 12 shows that there was a sharp increase in construction and demolition waste generation between 2014 and 2017.

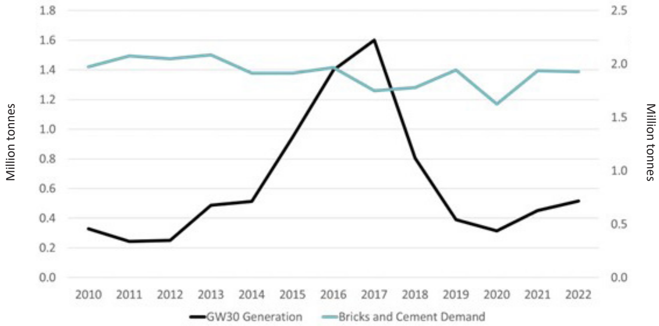


Figure 12: Construction and demolition waste generation (left axis) and the demand for bricks and cement (right axis) in the CoCT.

Due to this large spike in construction and demolition waste, a simplified Urban metabolism inspired approach was used to forecast the generation of construction and demolition waste, rather than trying to estimate or account for what could be an apparent cyclical construction and demolition waste trend. The tonnes of construction and demolition waste were compared to the total tonnes of bricks and cement demand over the period 2010- 2022. This fraction gives the medium to long-term expected annual movement of construction materials from one stockpile (infrastructure and buildings) to construction and demolition waste stockpiles.

For every tonne of bricks and cement that is demanded in the CoCT, it is, therefore, estimated that 330 kg of construction and demolition waste is generated, as can be seen in Figure 13.

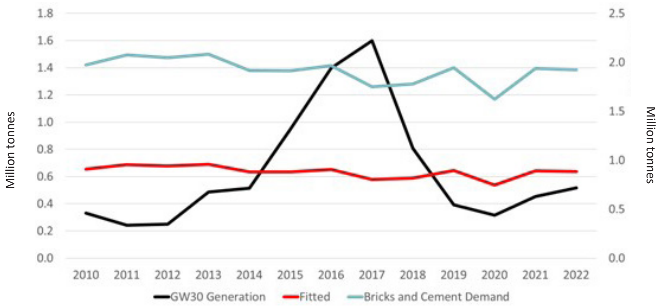


Figure 13: Construction and demolition waste generation and estimated generation (left axis) and the demand for bricks and cement (right axis) in the CoCT.

The rate of change from 2022 to 2023, 2028 and 2053, respectively was used to forecast construction and demolition waste supply for all the districts in the WC FDM™, despite the assumption that the turnover rate from buildings and infrastructure to stockpiles at waste facilities outside the CoCT municipality will be lower. However, as urbanisation, urban sprawl, and densification increase, the assumption might not be too unrealistic. This leads to a provincial construction and demolition waste forecast as can be seen in Figure 14.

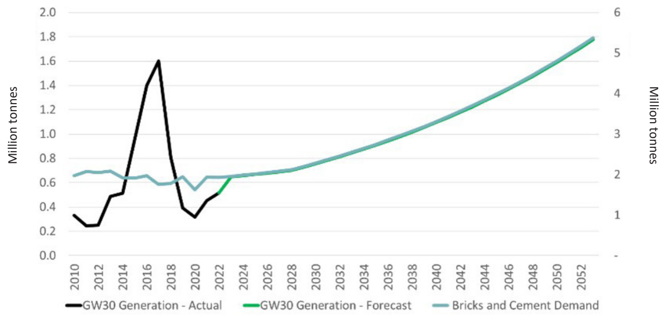


Figure 14: Bricks and cement demand for the CoCT and GW30 waste generation forecast.

Table 3 shows the forecast generation of construction and demolition waste. Given that the medium to the long-term tempo of construction and generation waste supply can be predicted by the growth in demand for bricks and cement in the CoCT, construction and demolition waste generation in the Western Cape is set to increase 3.44 times by 2053.

Table 3: Forecast construction and demolition waste generation for the Western Cape (million tonnes).

Origin	Actual	Forecast		
	2022	2023	2028	2053
CoCT	0.52	0.65	0.70	1.77
Rest of Province	0.29	0.36	0.39	1.00
Total	**0.81**	**1.01**	**1.09**	**2.77**

Highlights

- Municipal waste reduction initiatives have seemingly been reducing the waste generation cumulatively by 34 000 tonnes per year since 2010 up until 2021, given that the generation is explained by the demand for processed foods and beverages in the CoCT.
- Municipal waste forecasts for the CoCT based on demand for processed foods and beverages, in the absence of additional waste reduction measures such as recycling and reuse, are expected to increase to 2.6m tonnes per year.
- Garden waste generation is expected to double by 2053 based on the forecast of fertilizer demand in the CoCT.
- Construction and demolition waste is expected to grow the fastest of the three waste streams, mentioned in this chapter based on the forecast of bricks and cement demand in the CoCT.

The Western Cape Freight Demand Model historically included all modes of transport except air freight data. It was first included in the 2020 WC FDM™ update, but with limited integration due to the unavailability of detailed domestic air freight data. The focus of this update, even though the air freight volumes are very low, was to explore various potential data sources to obtain more detailed domestic air freight data.

Data gathering

While sufficient and reliable data is available for international air freight values and volumes, sparse data is available for domestic air freight volumes, specifically, data disaggregated by origin-destination and commodity. Commodity-related information is provided as a general description at best, yet commodity detail is usually completely absent.

The cause of this knowledge gap has been a significant topic of discussion within government and industry, with the following reasons often provided:

- The domestic air freight market's relatively small impact on economic growth;
- Data anonymity concerns since the market is relatively small, making it easy to trace the origin of data if information is shared;
- Owners of domestic air freight data want to protect their competitive advantage and intellectual property;
- Precise commodity-level information rarely being captured for most air freight parcels;
- Insufficient levels of awareness and promotion of the Western Cape's important and growing air freight agenda; and
- A lack of collaboration, information-sharing and transparency between air freight service operators.

Way forward

As evident from the details above, there is a definite need for a domestic air freight database to be developed for the Western Cape. Government and industry stakeholders emphasised the need to improve the availability, reliability and level of detail of domestic air freight data since the market space is key to economic job creation and competitiveness in the province. The presence of such a database would also allow for a more integrated and detailed air transport view in the WC FDM™, similar to current capabilities for other freight transport modes.

While addressing this need has clear advantages, it is important to realise that bridging this knowledge gap would be a complicated and resource-intensive task. The previously mentioned stakeholder engagements revealed that the creation of such a database will require active involvement from the South African Reserve Bank (SARB) and the South African Revenue Service (SARS). Furthermore, the creators of this envisaged database will need to get buy-in from air freight service operators such as South African Airways (SAA) and Airlink to ensure sufficient levels of data availability and transparency. Collaboration with South African airports, especially CTIA, and air transport-related industry associations and researchers/experts will also be vital. Moreover, all collaborating parties will need to help establish well-designed and purposeful data-capturing processes to ensure future air data is reliable, detailed and disaggregated by origin-destination and commodity. Since competitive advantage and intellectual property are of considerable concern to many of these parties, both government and industry will need to assure how data-sharing can be beneficial to all stakeholders concerned.

Overview of international air freight

In 2022, there were 52 392 freight tonnes transported via CTIA, whereof 29 859 tonnes (57%) were exported and 22 533 tonnes (43%) were imported. This shows a growth in total trade of 25.7% (10 727 tonnes) from the 2021 volumes of 41 665 tonnes; and 64% (20 463 tonnes) from the 2020 volumes of 31 929 tonnes. However, air trade volumes are still lower than the 63 015 tonnes transported in 2019. The extent of air freight arriving (import) and departing (export) from CTIA is depicted in Figure 1.

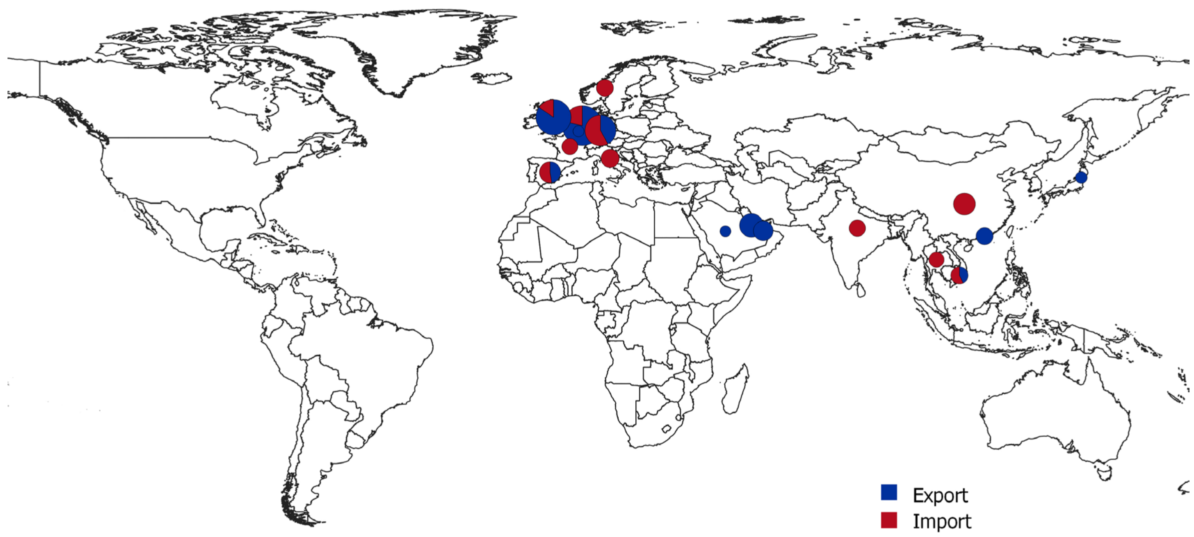


Figure 1: Map showing the import and export freight volumes for Cape Town International Airport in 2022

GAIN GROUP
Insight drives growth

Tables 1 and 2 below show how the most significant air freight commodities have changed between 2020 and 2022 for exports and imports respectively. As seen in Figure 2 and Table 1, CTIA predominantly exports food in its role as a facilitator of international trade. Note that food trade relates to the commodity groups of fresh foods; frozen foods; and foodstuff and beverages for human consumption (see detailed breakdown in Tables 1 and 2 for exports and imports). Apart from food-related commodities, the most air trade volumes in 2022 are related perishable Non-Foods (4 338 tonnes); clothing and accessories (2 993 tonnes); machinery for general industrial uses (1 936 tonnes); other chemicals & products (1 342 tonnes) and pharmaceuticals (1 299 tonnes). Interestingly, while their overall trade volumes are relatively high, no perishable non-foods and frozen foods are imported via CTIA. Furthermore, while 2022's export and import volumes are much higher than in 2021, they are still lower than those traded in 2019.

Table 1: The most significant Cape Town air freight commodities between 2020 and 2022 based on export trade volumes

Exports by commodity in tonnes *(% of total exports)*	2020	2021	2022
Food	9631 (55.8%)	11289 (52.5%)	17032 (57%)
Foods, Fresh	*8085 (46.8%)*	*8060 (37.5%)*	*14604 (48.9%)*
Foods, Frozen	*665 (3.8%)*	*1566 (7.3%)*	*1254 (4.2%)*
Foodstuffs & Beverages for human consumption	*882 (5.1%)*	*1663 (7.7%)*	*1174 (3.9%)*
Perishable Non-Foods	2351 (13.6%)	4187 (19.5%)	4338 (14.5%)
Basic industrial raw materials	257 (1.5%)	703 (3.3%)	898 (3%)
Machinery for general industrial uses	494 (2.9%)	173 (0.8%)	651 (2.2%)
Parts & components : power, agriculture, construction, mining, handling	35 (0.2%)	213 (1%)	578 (1.9%)
Odors & Flavours	312 (1.8%)	414 (1.9%)	496 (1.7%)
Consumer goods for personal consumption	226 (1.3%)	516 (2.4%)	495 (1.7%)
Clothing & Accessories	376 (2.2%)	393 (1.8%)	489 (1.6%)
Colours & Dyes	835 (4.8%)	356 (1.7%)	460 (1.5%)
Other chemicals & products	295 (1.7%)	142 (0.7%)	412 (1.4%)
Not else specified	2458 (14.2%)	3132 (14.4%)	4010 (13.5)
Total exports	**17 269**	**21 518**	**29 859**

Table 2: The most significant Cape Town air freight commodities between 2020 and 2022 based on import trade volumes.

Imports by commodity in tonnes *(% of total imports)*	2020	2021	2022
Food	1656 (11.3%)	3013 (15%)	2914 (12.9%)
Foodstuffs & Beverages for human consumption	*842 (5.7%)*	*1757 (8.7%)*	*1483 (6.6%)*
Foods, Fresh	*814 (5.6%)*	*1256 (6.2%)*	*1432 (6.4%)*
Clothing & Accessories	1604 (10.9%)	1846 (9.2%)	2504 (11.1%)
Pharmaceuticals	439 (3%)	864 (4.3%)	1299 (5.8%)
Machinery for general industrial uses	577 (3.9%)	1090 (5.4%)	1285 (5.7%)
Other chemicals & products	382 (2.6%)	685 (3.4%)	929 (4.1%)
Semi-manufactured industrial consumables	481 (3.3%)	724 (3.6%)	825 (3.7%)
Semiconductors	1665 (11.4%)	700 (3.5%)	811 (3.6%)
Machinery & apparatus for scientific, medical or technical purposes	656 (4.5%)	922 (4.6%)	724 (3.2%)
Consumables for packaging & transportation of goods	576 (3.9%)	683 (3.4%)	700 (3.1%)
Consumer goods for household consumption	491 (3.3%)	855 (4.2%)	693 (3.1%)
Land Vehicle Parts	461 (3.1%)	487 (2.4%)	647 (2.9%)
Not else specified	5673 (38.8%)	8278 (41%)	9201 (40.8%)
Total imports	**14 660**	**20 147**	**22 533**

As seen in Table 3, the largest trading partners for export air freight were the Netherlands and the United Kingdom, very similar to 2021. Export volumes to the Netherlands show further increase in 2022, higher than the 4 665 tonnes (13%) in 2019. Exports to the UK show a recovery of 28% (2 163 tonnes) from 2021. The presence of Vietnam, Belgium and Saudi Arabia, although at a low volume is interesting.

Table 3: The most significant Cape Town air freight trading partners between 2020 and 2022 based on export trade volumes

Export partner *(% of total exports)*	2020	2021	2022
Netherlands	3050 (17.7%)	4590 (21.3%)	5376 (18.0%)
United Kingdom	3278 (19%)	2329 (10.8%)	4492 (15.0%)
USA	1025 (5.9%)	1390 (6.5%)	2557 (8.6%)
Qatar	126 (0.7%)	500 (2.3%)	2428 (8.1%)
Germany	821 (4.8%)	917 (4.3%)	1737 (5.8%)
United Arab Emirates	576 (3.3%)	1098 (5.1%)	1679 (5.6%)
Hong Kong	1057 (6.1%)	891 (4.1%)	1255 (4.2%)
Spain	830 (4.8%)	1385 (6.4%)	923 (3.1%)
Japan	282 (1.6%)	603 (2.8%)	601 (2.0%)
China	745 (4.3%)	706 (3.3%)	
Italy	338 (2%)	648 (3%)	
Ethiopia	216 (1.3%)	607 (2.8%)	
Vietnam			550 (1.8%)
Belgium			526 (1.8%)
Saudi Arabia			523 (1.8%)

There is an interesting movement in the import trading partners in 2022, with the Netherlands surpassing Italy. Italy, France, Spain and Thailand shows a slight decrease in volumes from 2021. USA and India showed slight increases in volumes. (see Table 4).

Table 4: The most significant Cape Town air freight trading partners between 2020 and 2022 based on import trade volumes

Import partner *(% of total imports)*	2020	2021	2022
Germany	1468 (10%)	2215 (11%)	2397 (10.6%)
China	1213 (8.3%)	1692 (8.4%)	2062 (9.2%)
Netherlands	779 (5.3%)	1293 (6.4%)	1440 (6.4%)
Italy	722 (4.9%)	1609 (8%)	1422 (6.3%)
USA	640 (4.4%)	994 (4.9%)	1371 (6.1%)
Norway	605 (4.1%)	1011 (5%)	1250 (5.5%)
India	549 (3.7%)	722 (3.6%)	1161 (5.2%)
France	694 (4.7%)	1044 (5.2%)	1111 (4.9%)
Spain	815 (5.6%)	1146 (5.7%)	1016 (4.5%)
Thailand	944 (6.4%)	1046 (5.2%)	999 (4.4%)
United Kingdom	618 (4.2%)	779 (3.9%)	823 (3.7%)
Vietnam			734 (3.3%)

As seen in Table 5, CTIA's largest air freight food trade partners in 2022 are the United Kingdom, Netherlands, Qatar. In the previous years, the volumes of Qatar were significantly lower.

Table 5: The most significant Cape Town air freight trading partners between 2020 and 2022 based on food trade volumes

Food trade partner *(% of total food trade)*	2020	2021	2022
United Kingdom	2715 (24.1%)	1780 (12.4%)	3750 (18.8%)
Netherlands	1471 (13%)	1982 (13.9%)	2466 (12.4%)
Qatar	120 (1.1%)	485 (3.4%)	2363 (11.8%)
United Arab Emirates	449 (4%)	932 (6.5%)	1518 (7.6%)
Hong Kong	1020 (9%)	846 (5.9%)	1226 (6.1%)
Norway	568 (5%)	944 (6.6%)	1194 (6%)
Spain	616 (5.5%)	1590 (11.1%)	827 (4.1%)
USA	162 (1.4%)	138 (1%)	786 (3.9%)
Vietnam	652 (5.8%)	362 (2.5%)	504 (2.5%)
Saudi Arabia	102 (0.9%)	148 (1%)	421 (2.1%)
Germany	253 (2.2%)	521 (3.6%)	338 (1.7%)
France	103 (0.9%)	142 (1%)	314 (1.6%)
Italy	66 (0.6%)	110 (0.8%)	175 (0.9%)
Japan	55 (0.5%)	64 (0.4%)	59 (0.3%)
Belgium	32 (0.3%)	66 (0.5%)	37 (0.2%)
India	16 (0.1%)	37 (0.3%)	9 (0.04%)
Thailand	0 (0%)	2 (0.01%)	6 (0.03%)

Table 1 below lists all the manufacturing freight flows that originate within the Western Cape (intra-provincial and outgoing traffic). The grouping 'Other commodities' is also detailed in Table 1.

Table 1: Manufacturing freight flows that originate within the Western Cape (2022)

Commodity	Million tonnes 2022	Percentage contribution
Processed Foods	8.74	30.2%
Beverages	3.17	11.0%
Diesel	2.52	8.7%
Petrol	2.18	7.5%
Cement	2.13	7.4%
Other Manufacturing Industries	1.65	5.7%
Animal feed	1.59	5.5%
Bricks	1.25	4.3%
Other Commodities:		
Iron & Steel	0.86	3.0%
Other Petroleum Products	0.65	2.2%
Slaughtered animal meat	0.49	1.7%
Fertilizer	0.43	1.5%
Metal products, machinery and electronic equipment	0.43	1.5%
Jet fuel	0.39	1.4%
Chemicals	0.34	1.2%
Textile Products	0.34	1.2%
Paper	0.31	1.1%
Wood timber and products	0.27	0.9%
Scrap metals	0.24	0.8%
Pharmaceutical Products	0.20	0.7%
Soya bean products	0.16	0.6%
Gas in Pipes	0.15	0.5%
Non-Ferrous Metal Products	0.13	0.5%
Recycled paper	0.13	0.4%
Printing and Publishing	0.08	0.3%
Motor Vehicle Parts & Accessories	0.04	0.1%
Transport Equipment	0.02	0.0%
Pulp of wood and paper	0.00	0.0%
Motor vehicles and trucks	0.00	0.0%
Tobacco Products	0.00	0.0%
Wood chops	0.00	0.0%
	28.90	100.0%

Other manufacturing industries consist of manufactured goods that can be classified by the following (HS2[1]) codes: (36) Explosives; pyrotechnic products; matches; pyrophoric alloys: certain combustible preparations. (71) Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal, and articles thereof; imitation jewellery; coin. (90) Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus: parts and accessories thereof. (91) Clocks and watches and parts thereof. (92) Musical instruments; parts and accessories of such articles. (93) Arms and ammunition; parts and accessories thereof. (95) Toys, games and sports requisites; parts and accessories thereof. (96) Miscellaneous manufactured articles. (97) Works of art, collectors' pieces and antiques.

[1] Harmonised System is a standardised numerical method of classifying traded products. The first two digits (HS-2) identify the chapter the goods are classified in,.