WESTERN CAPE FREIGHT DEMAND MODEL

2021 Model | Report | December 2022

Western Cape Government

Transport and Public Works

Globally, successful national and regional macrologistics interventions have all been dependent on a data-driven approach. Evidence-based macrologistics planning for infrastructure investment and policy direction require activity-based data and costing, much the same as for logistics on a business level. In business, the trade-offs between various strategic alternatives and investment choices are difficult without a disaggregation of all logistics activities and the same is true for national and regional logistics planning. Business logistics is about flows - the forward flow of commodities through value chains, reverse flow of funds and the bi-directional flow of information. For policy and infrastructure investment, flow on a national and regional scale must be understood as well; a need that can be fulfilled with a flow model, based on demand. In the case of South Africa, a national freight flow model captures freight flows between 372 districts on 5 modes, namely road, rail, maritime, pipeline and aviation, and for 83 commodities for export, import and domestic freight, over a 30-year forecast horizon.

Demand-based flow models have been highly successful in the developing world. In India, using such a model led to the identification of various infrastructure gaps[1]. In Uzbekistan, it informed a new transport policy for the country[2] and in Mongolia[3] it assisted with the identification of various value chains and the integrated logistics infrastructure investments that could assist in sizeable economic growth for the country. In South Africa, the model assisted with, and often provided the basis for, various policy documents such as Moving South Africa (1998), the National Freight Logistics Strategy (2005), and The National Infrastructure Plan (2022).

---

[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].

A freight flow model provides information on flows throughout the region and can, for the present, indicate the volume of freight on each transport mode in that region and can also assign 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. The demand side can be influenced; for instance, what will the effect on infrastructure be with certain industrialisation actions, and which industrialisation strategies will best be enabled by specific interventions? Also, the cost-benefit analysis of modal choices, terminals, freight villages and special economic zones is enabled – all of which have been illustrated successfully on a global scale. Policy interventions can also be evaluated; such as the cost of congestion measures in cities, the effect of loading restrictions and law enforcement. In all cases, because activity (freight flows) and the cost drivers of these activities are known, the systemic effect of each infrastructure and policy decision can be modelled.

The South African transport and logistics industry is currently under extreme pressure and faces many challenges not only due to the effect of COVID but more specifically due to the inefficiencies within Transnet and the railways' inability to service the industry and contribute to the South African economy. The industry is starting to lose confidence in the Government's ability to intervene and is starting to position themselves to take over certain areas of rail operations in South Africa. The pressure is on National and Provincial government to ensure collaboration with industry to address the challenges of the transport and logistics industry in South Africa.

The Western Cape Provincial Government (WCG) has been at the forefront in understanding that a data driven approach to take on these challenges is critical and has developed the Provincial Freight Strategy to initiate sustainable freight transport delivery in the province and also invested in the development of the Western Cape Freight Demand Model (WC FDM™) since the 2017/18 financial year. This the sixth iteration of the model and the basis for this report. This report is based on 2021 data and describes the sources of data for the updated model and the methodology followed and presents various results that support strategic decision-making and implementation of the Western Cape Freight Strategy. Compared to previous years, this report covers a limited number of chapters due to the short time between the last published report (April 2022) and this edition. However, the complete 2021 dataset is available for further analysis and reporting on request.

- EXECUTIVE SUMMARY 1-1
- METHODOLOGY 2-1
- WESTERN CAPE TRADE – MODAL SPLIT 3-1
- PROVINCIAL TRADE 4-1
- CORRIDORS 5-1
- SCENARIO 1: MODAL SHIFT 6-1
- DETAIL ON AIR FREIGHT DATA 7-1
- WASTE DATA GATHERING, FORECAST AND ANALYSIS PROCESS 8-1

Western Cape Freight Demand Model (WC FDM™)

Western Cape Government

Transport and Public Works

Executive summary

The WC FDM™ supports strategic decision-making in the implementation of the Western Cape Freight Strategy.

This report covers a limited number of chapters compared to previous years due to the short time between the last published report (April 2022) and this edition. The complete 2021 dataset is, however, available for further analysis and reporting on request.

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 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.

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 and air freight data, and publicly available industry and business data.

Provincial modal split

The total freight with an origin or destination in the Western Cape amounted to 142.2m tonnes in 2021, showing an increase of 5.9% from 134.3m tonnes in 2020. This is largely attributed to economic recovery after the impact of COVID. The modal split of the total Western Cape freight is 57% on road and 43% on rail. For GFB[1] freight, 98% is transported on road and 2% on rail. Rail showed a 2% drop in modal split from 96% (road) and 4% (rail) in 2019 and 2018.

Rail is used mainly for low-value, bulk agricultural and mining (e.g., iron ore) commodities. Fruit presents a major opportunity that has not been realised due to the lack of consolidation facilities and rail freight service levels. The manufacturing sector is dominant in GFB freight volumes but continues its declining trend. Opportunities exist in the Western Cape for long-distance GFB rail freight.

---

[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.

Provincial trade

The Western Cape GFB freight (63.6 million tonnes) is split between intra-Western Cape freight (20.6 million tonnes), freight transported to other provinces (24.6 million tonnes) and freight received from other provinces (18.4 million tonnes). Waste is an intra-provincial flow only and amounts to 2.7 million tonnes (13% of intra-provincial flow). Almost half (47%) of intra-Western Cape freight and 77% of freight to other provinces, amounting to 28.7 million tonnes, consists of manufacturing commodities. Processed foods represent the largest manufactured commodity group (31%), followed by beverages (11%).

A slow economic recovery, after the effect of the COVID lockdown is visible due to the increase of freight in all sectors, despite the closure, of Saldanha Steel and the Astron Refinery.

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 24.4% of trade with KZN is related to the Port of Durban.

Corridors

Rail has a 2.0% tonnage market share of non-ring-fenced[2] total Western Cape road and rail freight. In terms of tonne-km, there was a decrease from 1.7% in 2020 to 1.1% in 2021. Corridor freight transport is dominated by road, with 99.2% non-ring-fenced tonnage market share on the N1 corridor, 99.5% on the N2 corridor and 86.6% on the N7 corridor. The average travel distance of freight on the N1, N2 and N7 is 1 389 km, 675 km and 392 km, 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.

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.

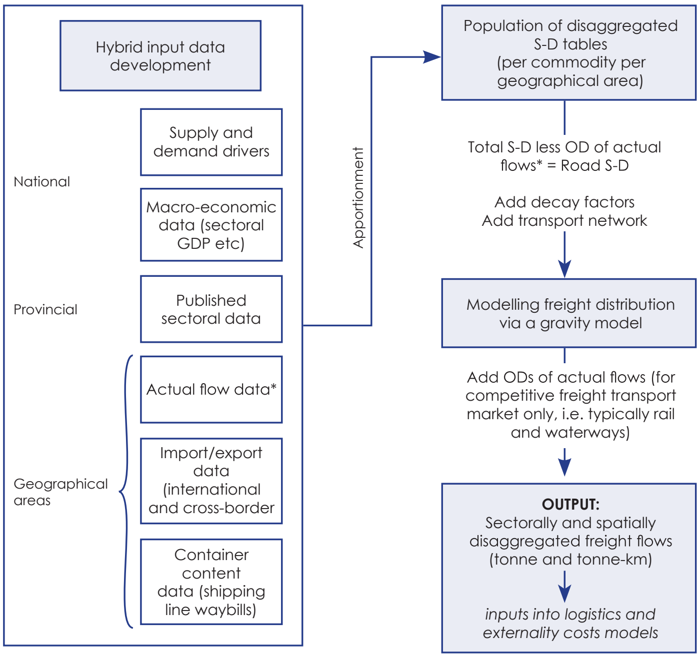
Air freight data

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.

[2] "Ring-fenced" freight is freight that is usually part of a specific ring-fenced system that is not impacted by provincial-level strategic interventions, for example iron ore from Sishen to Saldanha. Non-ring-fenced freight refers to the freight that falls outside of this definition.

Western Cape Freight Demand Model (WC FDM™) ***Methodology***

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 & Simpson, 2018)

The national model was first developed and used in 1998. The model was improved in 2006 to become a completely repeatable model, and has since been updated annually with Transnet sponsorship. 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 & 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.

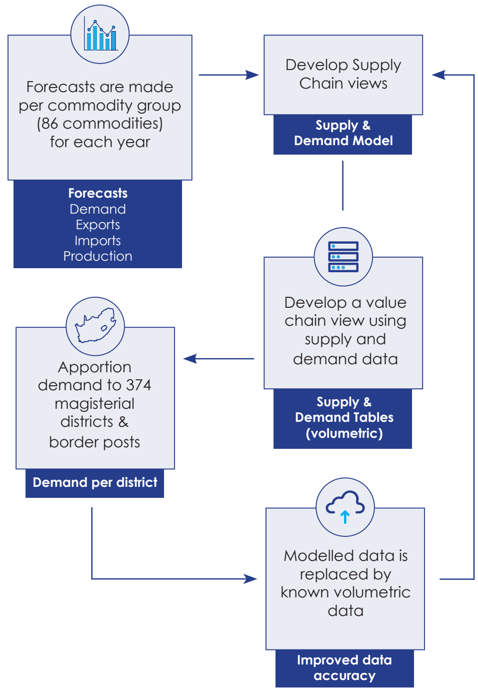


Figure 2: Econometric model

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, using 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 as an objective, readily-available variable. 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.

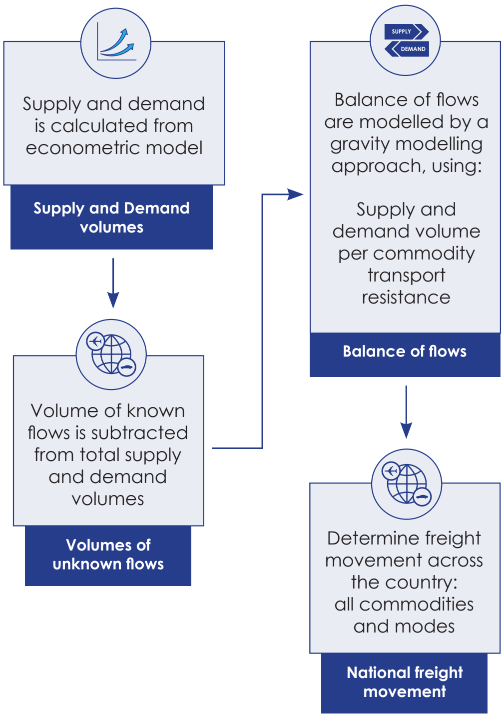


Figure 3: Flow Model

The Western Cape Freight Demand Model (WC FDM™)

The WC FDM™ 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, and pipeline). A geographic representation of the WC FDM™ districts is presented in Figure 4.

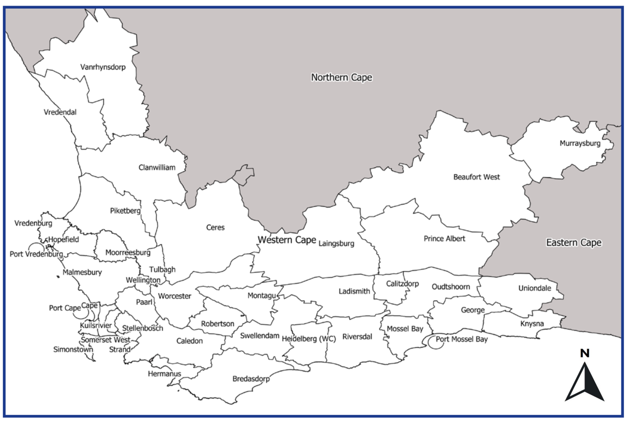


Figure 4: Geographical districts within the Western Cape

Data sources

During the development of the WC FDM™, 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 and air freight data; and
- Publicly available data for industry and businesses.

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

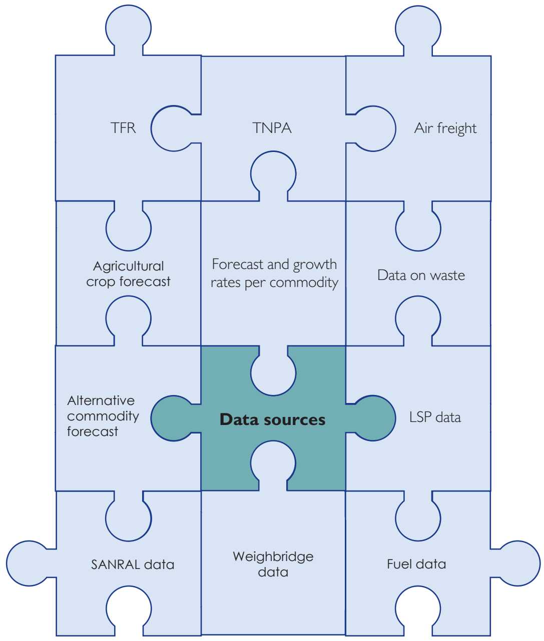


Figure 5: Data Sources

1. Forecasts and growth rates: Revised in line with the national FDM™ for imports, exports, production, intermediate demand and final demand/consumption in the WC FDM™.
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 WC FDM™ flows. It largely confirmed the modelled WC FDM™ 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: Included but not yet integrated with other modes of transport in the FDM™ as the origin destination (OD) detail is not available. See detail of the data challenges in the Air freight data chapter.

Refer to Chapter 6 of Havenga, Witthöft, De Bod and Simpson (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*. Published doctoral dissertation. Stellenbosch: University of Stellenbosch. http://hdl.handle.net/10019.1/1175.

Havenga, J.H. 2013. The importance of disaggregated freight flow forecasts to inform transport infrastructure investments. *Journal of Transport and Supply Chain Management, 7(1):1-7.*

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

Havenga, J.H. & Simpson, Z.P. 2018. National freight demand modelling: a tool for macrologistics management. *International Journal of Logistics Management,* 29(4):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 2021 is shown in Figure 1 and amounted to 142.2m tonnes, representing a 5.9% increase from the 134.3m tonnes in 2020. This is largely attributed from economic recovery after the impact of COVID.

The total tonnes per sector for road and rail are given in Figure 2. The waste data[1], consists of municipal waste, green 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 2021 data shows an increase for road tonnes across all sectors from 2020, led by manufacturing's near 3% increase - bringing it close to the 41m tonnes in 2019. This recovery is contrasted by the decrease in agriculture and manufacturing rail freight. The increase in mining is due to Namakwa Sands activity. The road G F B market share remained stagnant at 98% in 2021. Despite economic recovery, rail did not recover the freight it had in 2019 and 2018 when road had a 96% market share.

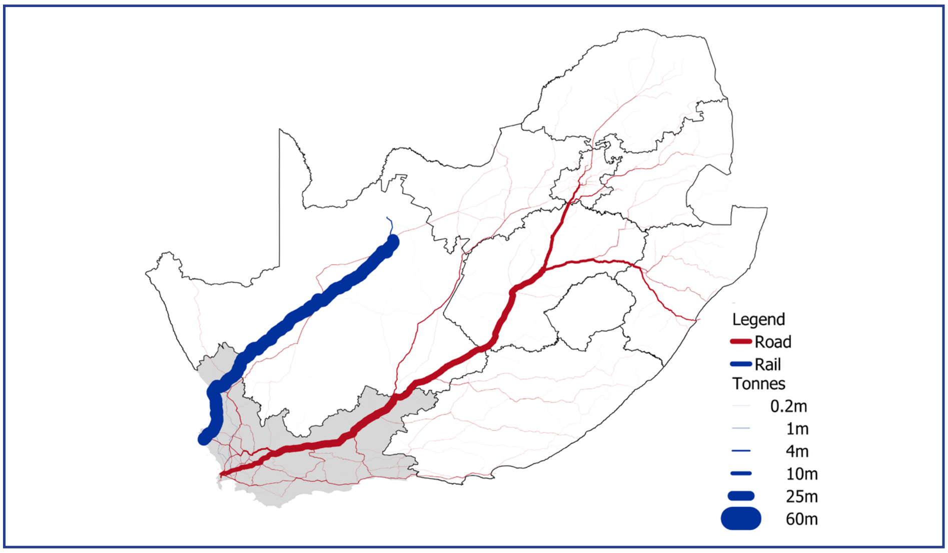


Figure 1: Total freight with an origin or destination in the Western Cape scaled to iron ore export line (2021)

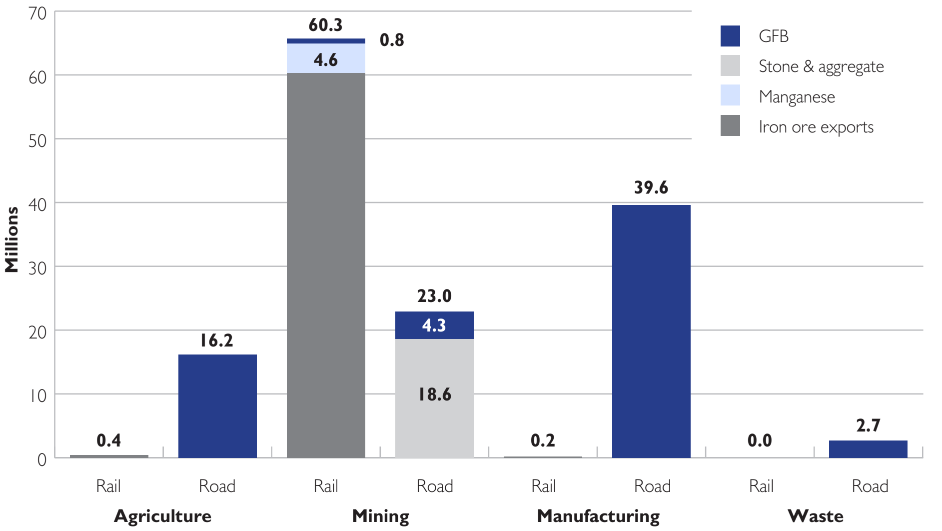


Figure 2: Total road and rail tonnes per sector in the Western Cape (2021)

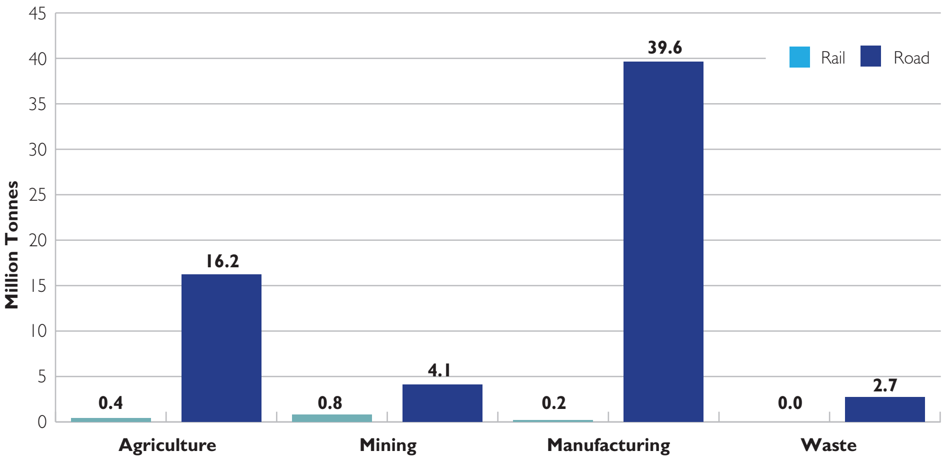


Figure 3: GFB road and rail tonnes per sector (2021)

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

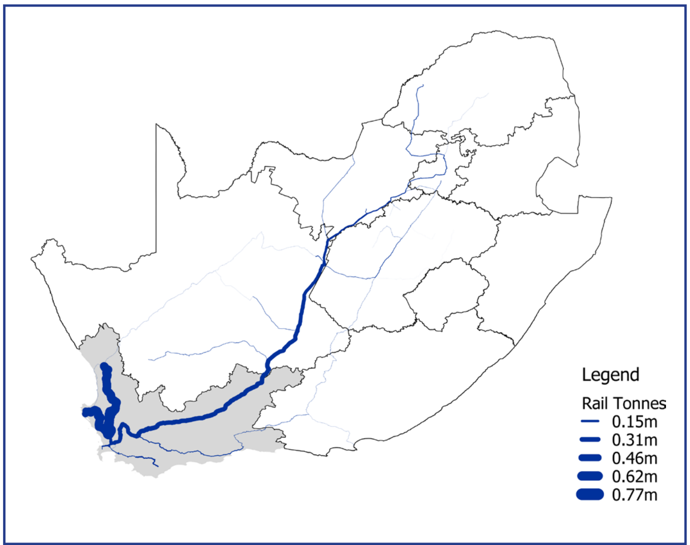


Figure 4: GFB rail freight that touches the Western Cape (2021)

Rail is mostly used in agriculture and mining, despite the loss of 144 364 tonnes of agricultural freight on rail in 2021 (from 510 632 to 366 268 tonnes), there was an increase of 191 330 tonnes of mining freight (from 579 774 to 771 104 tonnes). Of the 191 330 mining tonnes, 165 926 tonnes are titanium slag, which can only be moved for 8km from the Namakwa Sands Smelter to the Port of Saldanha on rail. Titanium slag on rail from the smelter to the port was, therefore, already on rail before but not accounted for in the WC FDM™ to date due to the way TFR data was processed previously. This offset was nullified by the loss of 105 688 tonnes of manufacturing freight (from 273 312 to 167 623 tonnes).

Agricultural dry bulk like wheat, maize and barley are still transported on rail to a limited extent but year-on-year volumes have declined; for instance, maize and wheat were 110 285 tonnes (38%) and 60 584 tonnes (75%) less respectively. Barley increased slightly from 160 986 tonnes in 2020 to 167 975 tonnes in 2021, which is still significantly lower than the 2019 volume of 232 866 tonnes. Grain sorghum increased by 4 400 tonnes (660%), which now accounts for 25% of the market share, 25% of the market share (up significantly from the 5% of before).

Fruit presents a major opportunity that has not been realised due to the lack of consolidation facilities, rail service levels and capacity. The closure of Saldanha Steel impacted the rail volumes significantly. 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. Previously, rail transported limestone, granite and other manufacturing industries. The further decline of 121 119 tonnes of iron & steel, caused the decline of manufacturing commodities, which have not recovered since 2020. 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 0.9m tonnes. This large decrease (from 2.1m tonnes) from 2020 is due to the absence of the movement of crude oil from the Port of Saldanha to the Astron Refinery, due to its closure. Production is expected to resume in 2023. The remaining movements were crude oil from the Port of Mossel Bay to the PetroSA refinery (0.7m tonnes) and gas from the offshore production wells to the Mossgas production platform (0.2m 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).

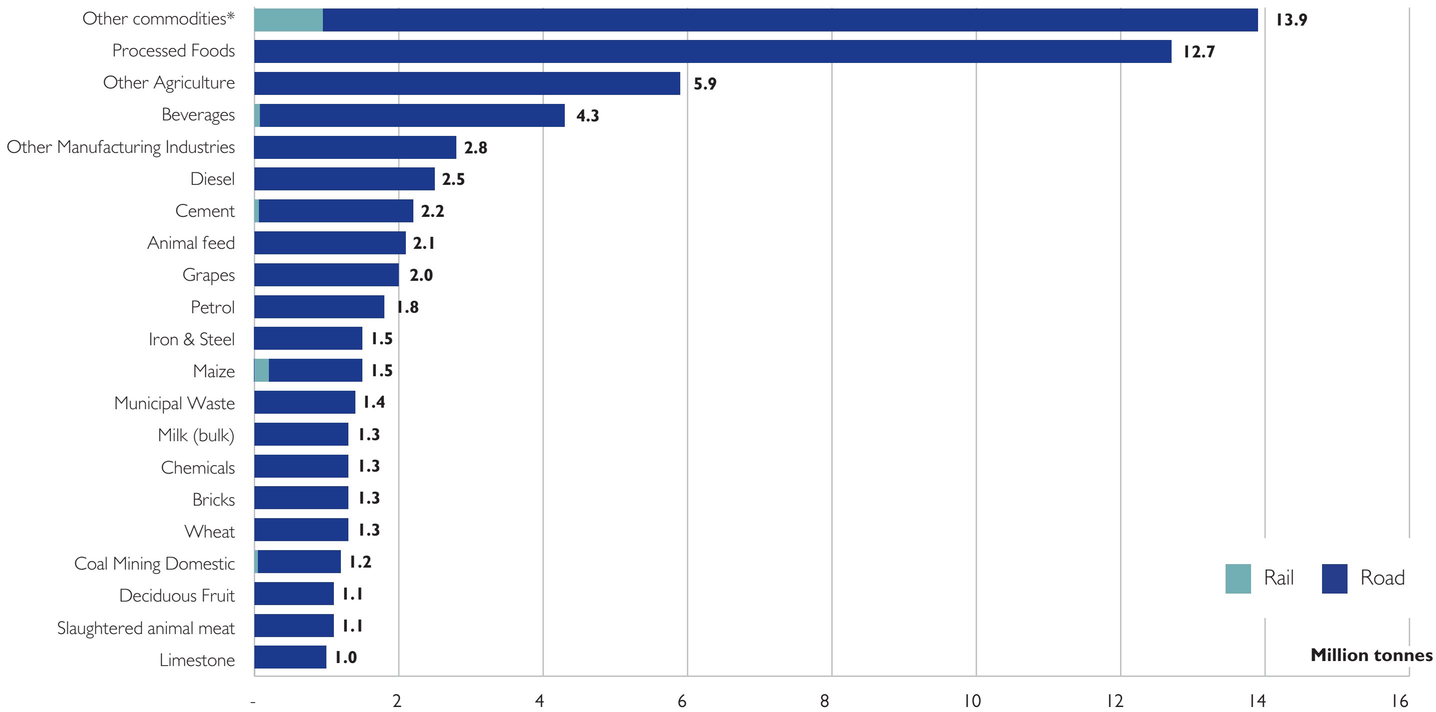


Figure 5: Western Cape related GFB freight volumes per commodity per mode (2021)

* 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.

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[2], 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[3], 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 whereas national rail tonnes and tonne-kms still declined further in 2021, as can be seen in Figure 6.

Note that it is mostly inter-provincial freight volumes that are growing, as the tonne-kms have been growing faster than tonnes since 2014. Whereas the national increase in volumes between 2018 and 2019 was driven by the three major export commodities: iron ore, manganese, and coal, iron ore and coal mining exports further declined significantly in 2021. Western Cape coal volumes on rail have mostly disappeared.

Table 1: Rail volumes and market share (2021 and 2020)

Commodity on Rail	Rail volumes (thousand tonnes)		Rail market Share	
	2021	2020	2021	2020
Ilmenite (Titanium ore)	406.8	363.7	56%	46%
Maize	178.1	288.4	12%	19%
Barley	168.0	161.0	59%	35%
Titanium slag	165.9	-	49%	0%
Zircon	112.6	109.4	75%	69%
Cement	58.2	64.8	3%	3%
Beverages	47.7	28.1	1%	1%
Coal Mining Domestic	36.3	25.1	3%	2%
Fertilizer	34.2	27.7	6%	6%
Rutile	28.8	68.2	15%	41%
Chemicals	21.8	19.7	2%	2%
Gypsum	20.7	7.9	13%	7%
Wheat	15.1	60.6	1%	5%
Grain Sorghum	5.1	0.7	25%	5%
Iron & Steel	4.7	125.8	0%	14%
Diesel	1.0	0.9	0%	0%
Other Manufacturing Industries	-	6.2	0%	0%
Granite	-	4.9	0%	7%
Limestone	-	0.6	0%	0%
Metal products, machinery and electronic equipment	-	-	0%	0%

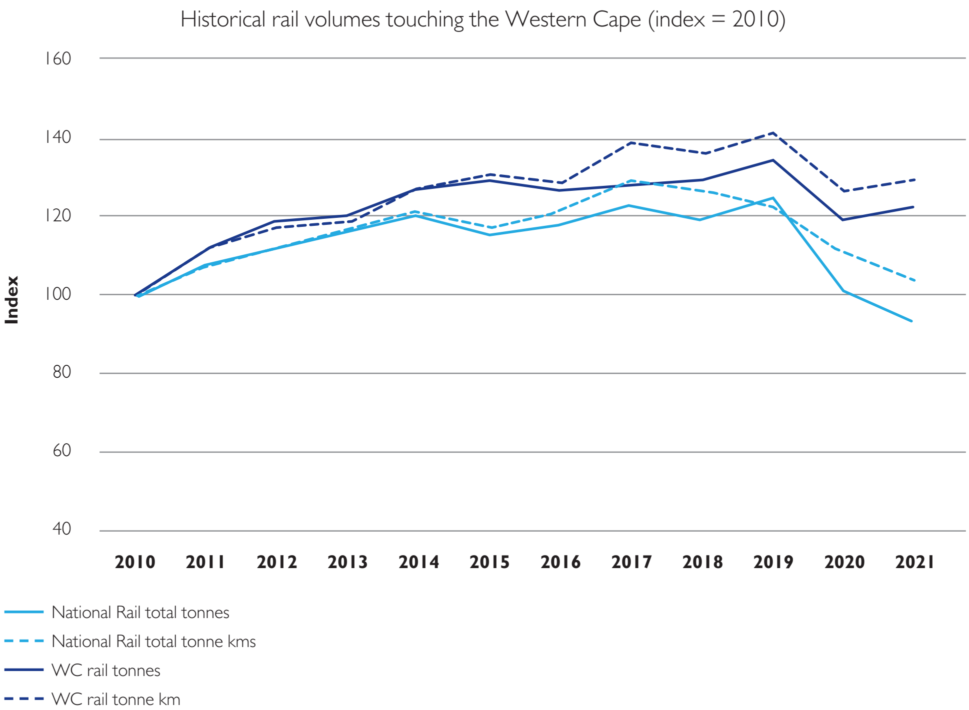


Figure 6: Time series of indexed rail tonnes and tonne-kms from 2010 to 2021 (index = 2010)

From the indexed GFB tonnes (i.e., excluding iron ore, manganese, and coal mining exports), it is evident that rail had a further decline in general freight market share (see Figure 7).

In 2015 and 2016, rail lost long-distance volumes, as the tonne-kms increased less than the tonnes for those two years. For the Western Cape, which has the longest average freight travel distance, it would make economic sense to try to increase rail market share on long-distance GFB freight where possible.

The decrease from 2018 continuing to 2021 in the Western Cape's GFB tonnes is attributed to a decrease in the market share of wheat, iron and steel, domestic coal, granite, other manufacturing industries and limestone.

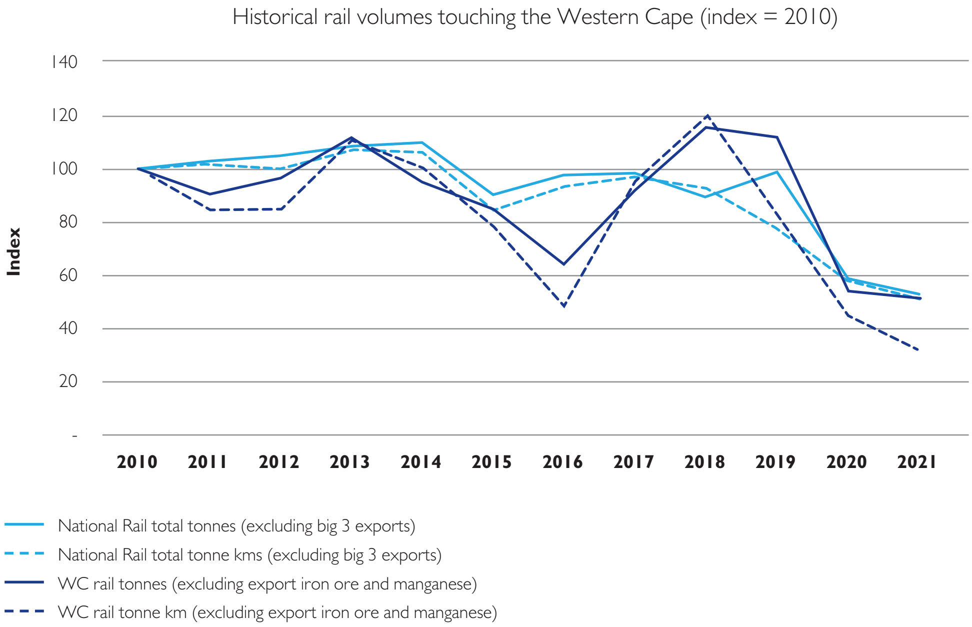


Figure 7: Time series of indexed GFB rail tonnes and tonne-kms from 2010 to 2021 (index = 2010)

Highlights

- Total road and rail freight (2021) with an origin or destination in the Western Cape amounted to 142.2m tonnes, showing an increase of 5.9% from the 134.3m tonnes in 2020 due to the recovery from the impact of COVID-19.
- Modal share in the Western Cape remained unchanged in 2021 (excluding air freight and pipelines) is 57% (road), 43% (rail) for total freight and 98% (road), 2% (rail) for GFB freight, marking no noticeable recovery from the 2020 2% drop in the modal split from 96% (road) and 4% (rail) in 2019 and 2018.
- The mining sector is dominant due to export iron ore.
- Pipeline freight amounted to 0.9m tonnes, of which most was crude oil moving from Mosselbay port to the PetroSA refinery. It is expected to increase with 1.2m tonnes in 2023 with the reopening of the Astron refinery.
- Air freight via Cape Town International Airport amounted to 41 665 tonnes, whereof most movements were related to exports. Overall, food was the most prevalent air freight commodity (18%).
- Rail is used mainly for mining and agricultural commodities which are low-value, bulk commodities.
- 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, and shows an increase from previous years, despite agriculture and manufacturing decreasing.
- Opportunities exist for rail transport of long-distance GFB freight in the Western Cape.

---

[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.

[2] **Intermodal:** Seamless use of more than one transport mode for a single shipment by unitising freight in a large container that can be easily transferred between modes. It differs from multimodal, which means the use of more than one mode in a shipment, in any form. **Domestic intermodal:** Intermodal transport within a country, or without crossing a quay wall, i.e. both the origin and destination of the shipment is in the country. Domestic intermodal technologies are, however, possible for land-based transport that crosses land borders, that are common in Europe. It is not so common in Southern Africa, but should develop in future.

[3] The Cape corridor is the main arteries that connect Gauteng and regions close to it with the larger Cape Town region. It consists of four major pieces of infrastructure, i.e. the N1, the alternative N12/N1 connection on road and the rail connections via Bloemfontein and Kimberly.

The 63.6m tonnes of Western Cape General Freight Business (GFB)[1] freight is split between 20.6m tonnes intra-Western Cape freight, 24.6m tonnes transported to other provinces and 18.4m tonnes received from other provinces.

Despite the absence of 1.2m tonnes of crude oil from Saldanha to the Astron refinery, there was a slight decrease in intra-Western Cape freight of 0.6m tonnes for 2021 (21.2m tonnes in 2020). Furthermore, the tonnes transported to and received from other provinces increased by 0.8m (23.8m tonnes in 2020) and 0.9m (17.5m tonnes in 2020) respectively in 2021. These flows are shown per sector in Figure 1. 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 13% (2.7m tonnes), it forms a substantial part of intra-provincial tonnes.

In 2021, the Western Cape sent 0.2m more tonnes of mining commodities to other provinces than in 2020, while receiving 0.9m tonnes less. Similarly, 0.4m and 1.6m tonnes more manufacturing commodities were sent and received, while agriculture commodities sent and received increased by 0.2m and 0.2m tonnes respectively. A slow economic recovery after the effect of the COVID lockdown is visible due to the increase of freight in all sectors, despite the closure of Saldanha Steel and the Astron Refinery.

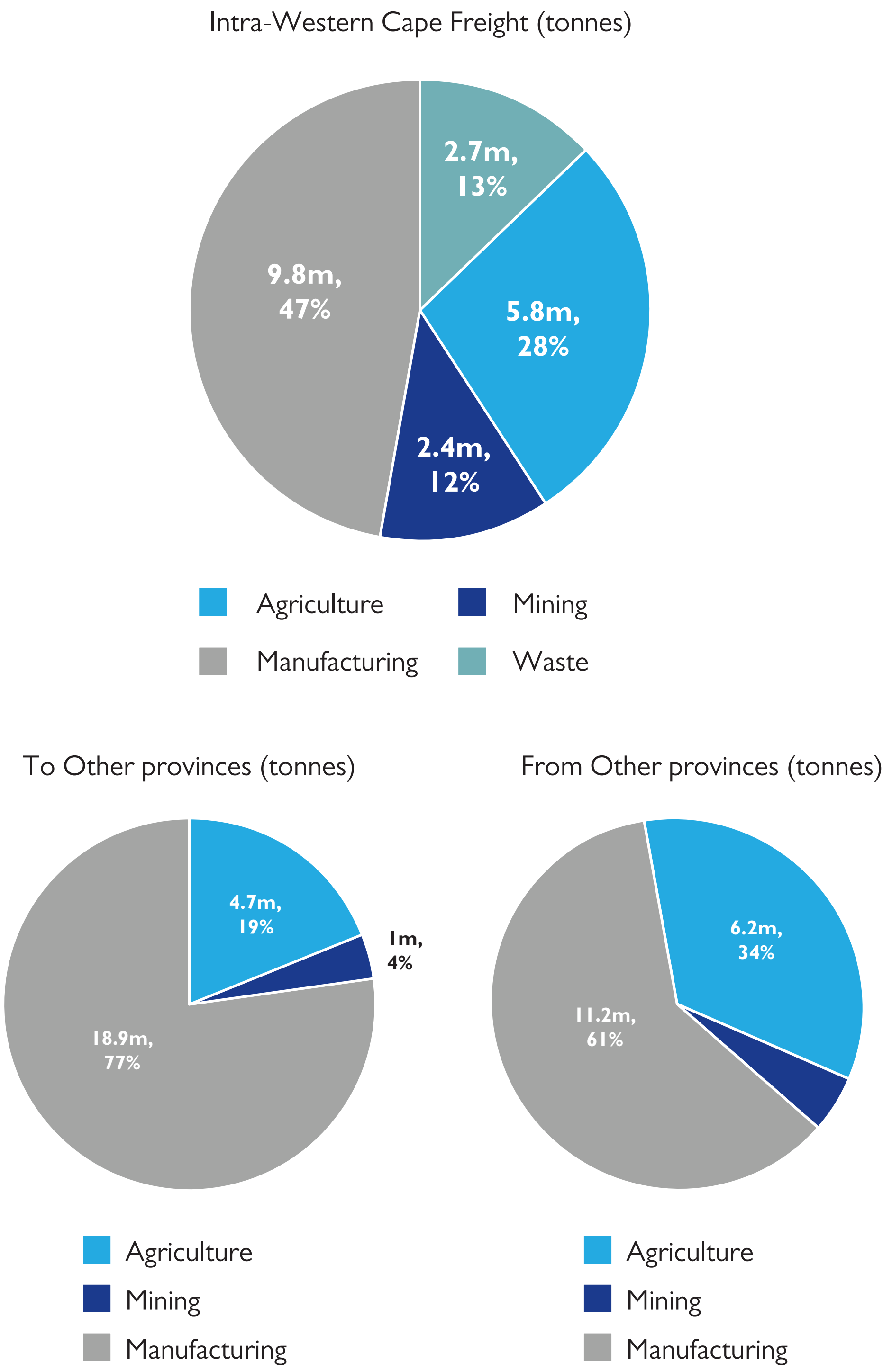


Figure 1: Provincial GFB freight-flows per sector (tonnes 2021)

[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 2 (i.e., the intra-Western Cape manufacturing freight flow tonnes, as well as the manufacturing tonnes flowing to other provinces, to depict the manufacturing base of the province). Of the total 28.7m tonnes of manufacturing commodities that originate from the Western Cape, only 9.8m tonnes are distributed inside the province while 18.9m tonnes are sent to the rest of the country. The largest commodity group is processed foods, which contributes 31%, 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.

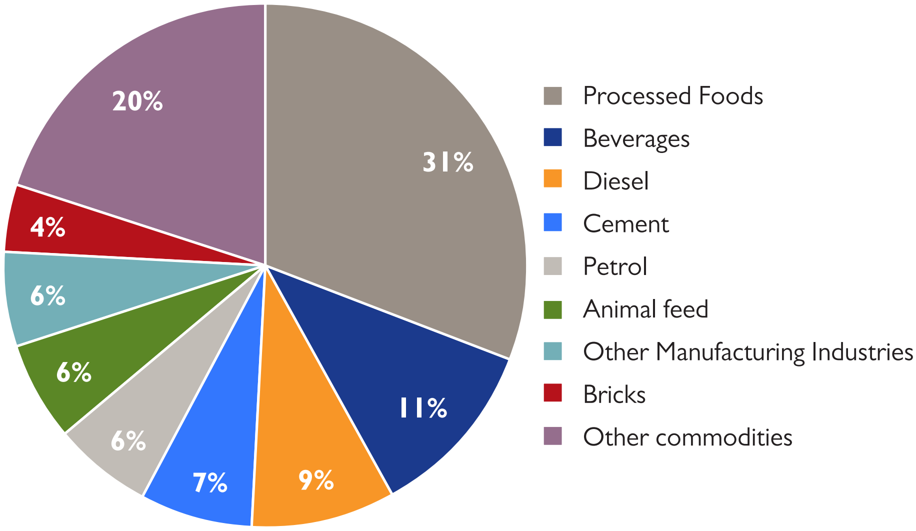


Figure 2: Manufacturing commodities with origin Western Cape (intra-provincial and outgoing, 2021)

KwaZulu-Natal again dominates as the Western Cape's main GFB trading partner, followed closely by Gauteng. The Western Cape receives 5.8m tonnes (31.5%) of its GFB freight from KwaZulu-Natal and 2.9m tonnes (16.0%) from Gauteng. Of all the GFB freight originating from the Western Cape, 5.2m tonnes (21.5%) are destined for Gauteng and 4.5m tonnes (18.8%) for KwaZulu-Natal, as shown in Figure 3. If it was not for the Port-related trade with KZN, Gauteng would have been the Western Cape's biggest trading partner, because 24.4% of trade with KZN is related to the Port of Durban.

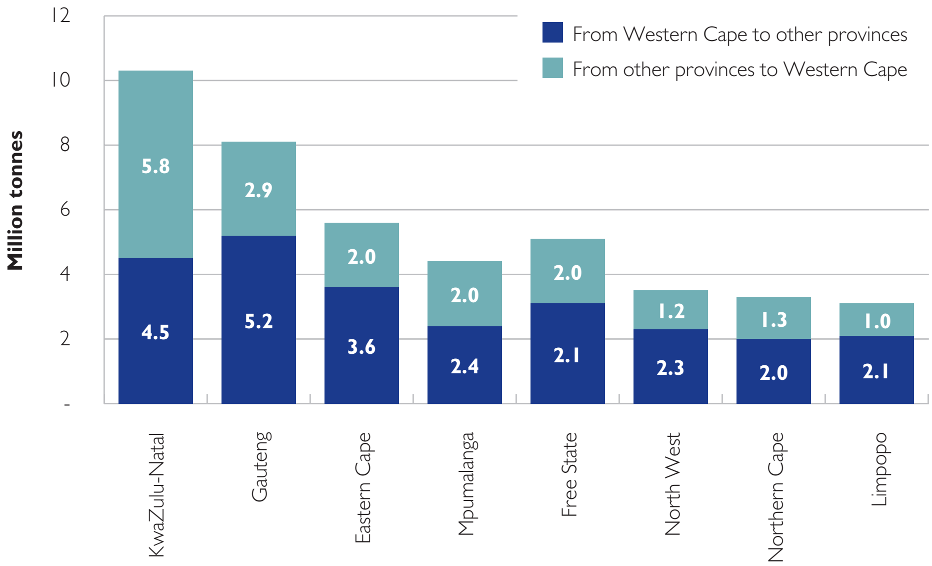


Figure 3: Western Cape inter-provincial GFB freight (2021)

Highlights

- The Western Cape GFB freight (63.6m tonnes) is split between intra-Western Cape freight (20.6m tonnes), freight transported to other provinces (24.6m tonnes) and freight received from other provinces (18.4m tonnes).
- Waste is an intra-provincial flow only and amounts to 2.7m tonnes (13% of intra-provincial flow).
- Almost half (47%) of intra-Western Cape freight and 77% of freight to other provinces are manufacturing commodities, amounting to 28.7m tonnes.
- The largest commodity group in the Western Cape's manufacturing sector, is processed foods (31%), followed by beverages (11%).
- A slow economic recovery after the effect of the COVID lockdown is visible due to the increase of freight in all sectors, despite the closure of Saldanha Steel and the Astron Refinery.
- 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 24.4% of trade with KZN is related to the Port of Durban.

Corridors

To determine corridor freight for the N1, N2 and N7, the magisterial 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)

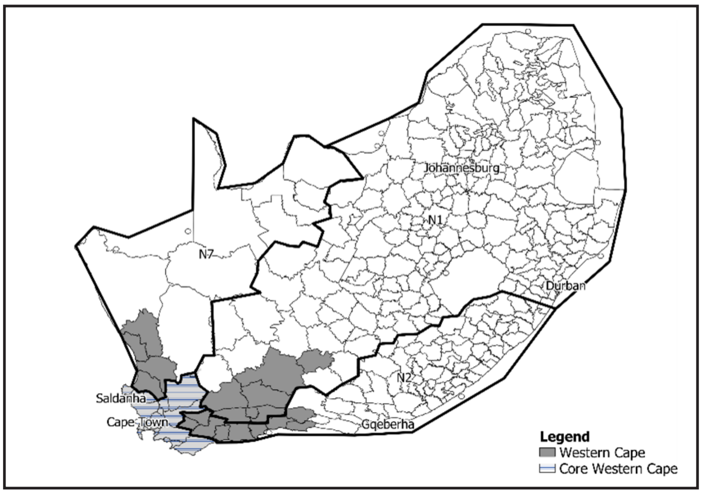


Figure 1: Corridor definitions for Western Cape freight

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.

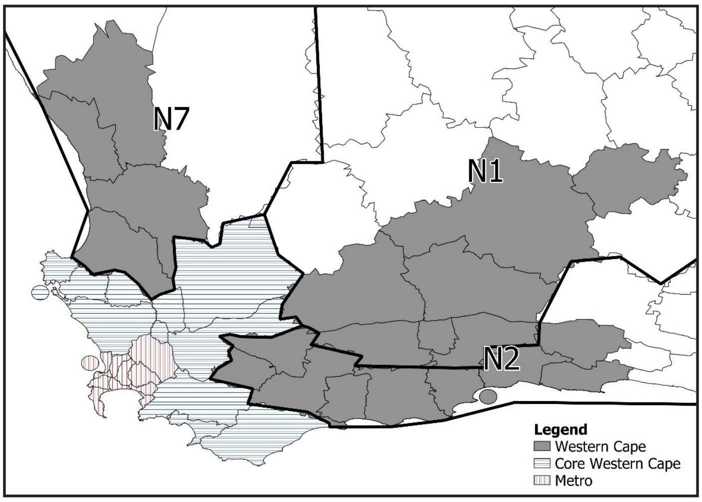


Figure 2: OD pairs for Cape Town Metropolitan freight

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 the volumes and percentage split of the General Freight Business (GFB)[1] road and rail freight per zone.

Table 1: GFB road and rail freight (tonnes) per zone (2021)

Zonal Grouping	Road tonnes (million) (% of zone freight)	Rail tonnes (million) (% of zone freight)	Total (million)
N1 Corridor traffic	29.6 (99.2%)	0.23 (0.8%)	29.8
N2 Corridor traffic	7.5 (99.5%)	0.04 (0.5%)	7.6
N7 Corridor traffic	3.5 (86.6%)	0.55 (13.4%)	4.1
Metropolitan traffic	7.0 (99.9%)	0.01 (0.1%)	7.0
Core Western Cape	5.9 (93.7%)	0.40 (6.3%)	6.3
Non-corridor traffic	9.1 (99.1%)	0.09 (0.9%)	9.1
Total	**62.6 (99.0%)**	**1.3 (2.0%)**	**63.9**

With the closure of Saldanha Steel, the 3.5 million tonnes of N7 corridor freight did not include any freight which is deemed "ring-fenced", namely, freight that is usually part of a specific ring-fenced system that is not impacted by provincial-level strategic interventions. More than half of the freight on the N1 corridor is food commodities.

[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.

This is evident from Table 2 which excludes any previously ring-fenced freight. The very low contribution of rail to N1 corridor freight, which is a very long corridor, is an issue of great concern that needs to be resolved.

Table 2: GFB (also excluding domestic iron ore and coal) road and rail freight (tonnes) per zone (2021)

Zonal Grouping	Road tonnes (million) (% of zone freight)	Rail tonnes (million) (% of zone freight)	Total (million)
N1 Corridor traffic	28.9 (99.2%)	0.23 (0.8%)	29.1
N2 Corridor traffic	7.5 (99.5%)	0.04 (0.5%)	7.6
N7 Corridor traffic	3.5 (86.4%)	0.55 (13.6%)	4.0
Metropolitan traffic	7.0 (99.9%)	0.01 (0.1%)	7.0
Core Western Cape	5.9 (93.7%)	0.40 (6.3%)	6.3
Non-corridor traffic	8.7 (99.4%)	0.05 (0.6%)	8.7
Total	**61.4 (98.0%)**	**1.3 (2.0%)**	**62.7**

Table 3 shows the tonne-km per zone.

Table 3: GFB (also excluding domestic iron ore and coal) road and rail freight (tonne-km) per zone (2021)

Zonal Grouping	Road tonne-kms (billion) (% of zone freight)	Rail tonne-kms (billion) (% of zone freight)	Total tonne-kms (billion)
N1 Corridor traffic	40.1 (99.3%)	0.26 (0.7%)	40.4
N2 Corridor traffic	5.1 (99.6%)	0.02 (0.4%)	5.1
N7 Corridor traffic	1.3 (84.1%)	0.25 (15.9%)	1.6
Metropolitan traffic	0.2 (99.9%)	0.00 (0.1%)	0.2
Core Western Cape	0.5 (96.1%)	0.02 (3.9%)	0.5
Non-corridor traffic	10.0 (99.5%)	0.05 (0.5%)	10.0
Total	**57.2 (98.9%)**	**0.6 (1.1%)**	**57.8**

The tonne-km view confirms a two-year contraction of long-distance rail market share (down from 1.7% in 2020), 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 road freight per corridor. Note that 47.1% of Western Cape road freight travels on the N1 road corridor, with an average distance travelled of 1 383 km, representing a 1.3% increase from 2019.

Table 4: Freight intensity per zone (2021)

Zonal Grouping	Road tonnes (million)	Percentage of total traffic
N1 Corridor traffic	29.1	46.4%
N2 Corridor traffic	7.6	12.1%
N7 Corridor traffic	4.0	6.4%
Metropolitan traffic	7.0	11.1%
Core Western Cape	6.3	10.0%
Non-corridor traffic	8.7	13.9%
Total	**62.7**	**100.0%**

Highlights

- Rail has a 2.0% tonnage market share of non-ring- fenced total Western Cape road and rail freight. In terms of tonne-kilometres, this is a decrease from 1.7% in 2020 to 1.1% in 2021.
- Corridor freight is dominated by road, with: 99.2% market share on the N1 corridor; 99.5% market share on the N2 corridor and 86.6% market share on the N7 corridor.
- The average travel distance of freight on the N1, N2 and N7 corridor is 1 389 km, 675 km and 392 km, respectively.
- More than half of N1 corridor freight is food commodities.
- Modal shift opportunities exist for long-distance road freight in the Western Cape.

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 2021 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 2021 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.

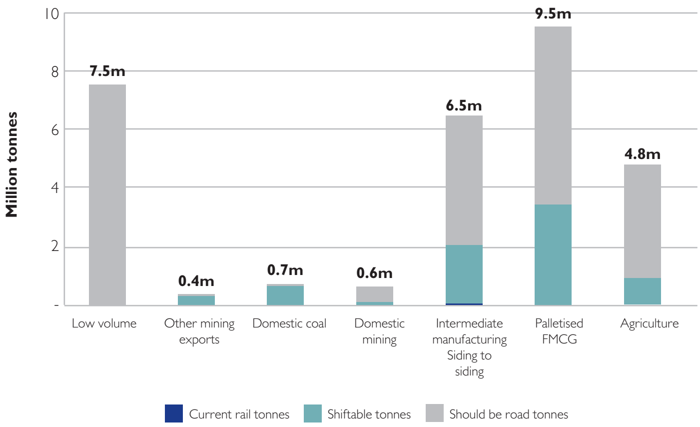


Figure 1: Modal shift opportunity per segment on the N1

Table 1: Modal shift opportunity per segment on the N1

Segment	Road tonnes	Rail tonnes	Shiftable tonnes
Low volume targetable	7 511 105	5 275	(0%)
Other mining exports	367 820	-	314 597 (85.5%)
Domestic coal	710 964	-	639 210 (89.9%)
Domestic mining	605 687	-	75 682 (12.5%)
Intermediate manufacturing - Siding to siding	6 410 539	57 276	1 970 748 (30.7%)
Palletised FMCG	9 515 431	689	3 440 645 (36.2%)
Agriculture	4 649 667	166 702	739 489 (15.9%)
Total	29 771 212	229 943	7 180 372 (24.1%)

Transport costs[2] on the N1 corridor for these segments are currently 15.1% 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 2052 this premium will be 16.3%. If the rail market share remains constant up to 2052 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)
2021 - Current market share	36.3	15.1%	4.77	375.1
2027 - Stagnant rail volumes	45.1	17.8%	6.81	497.3
2027 - Constant market share	45.0	17.7%	6.79	495.2
2027 - Growth market share	38.1	-	-	-
2052 - Stagnant rail volumes	79.7	16.3%	11.18	856.6
2052 - Constant market share	79.6	16.1%	11.02	845.3
2052 - Growth market share	68.3	-	-	-

[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.

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

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.

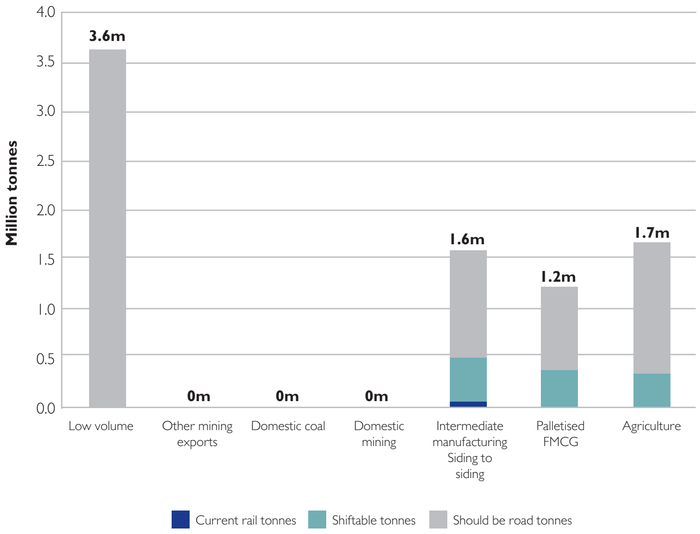


Figure 2: Modal shift opportunity per segment on the N2

Table 3: Modal shift opportunity per segment on the N2

Segment	Road tonnes	Rail tonnes	Shiftable tonnes
Low volume targetable	3 643 222	514	(0%)
Other mining exports	4 234	-	3 621 (85.5%)
Domestic coal	-	-	(0%)
Domestic mining	32 970	-	4 120 (12.5%)
Intermediate manufacturing - Siding to siding	1 559 657	30 864	473 228 (30.3%)
Palletised FMCG	1 209 037	7 150	357 415 (29.6%)
Agriculture	1 683 718	-	338 277 (20.1%)
Total	**8 132 838**	**38 528**	**1 176 661 (14.5%)**

Transport costs on the N2 corridor across all segments are currently 2.2% higher than they would be if all shiftable tonnes were transported by rail (see Table 4). If rail volumes remain stagnant this will be 2.0% by 2052.

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)
2021- Current market share	4.7	2.2%	0.10	30.0
2027 - Stagnant rail volumes	6.0	2.7%	0.16	41.5
2027 - Constant market share	6.0	2.6%	0.15	41.0
2027 - Growth market share	5.8	-	-	-
2052 - Stagnant rail volumes	9.6	2.0%	0.192	63.1
2052 - Constant market share	9.6	2.0%	0.189	62.5
2052 - Growth market share	9.4	-	-	-

N7 corridor

The key opportunity for modal shift on the N7 corridor is in agriculture, 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.

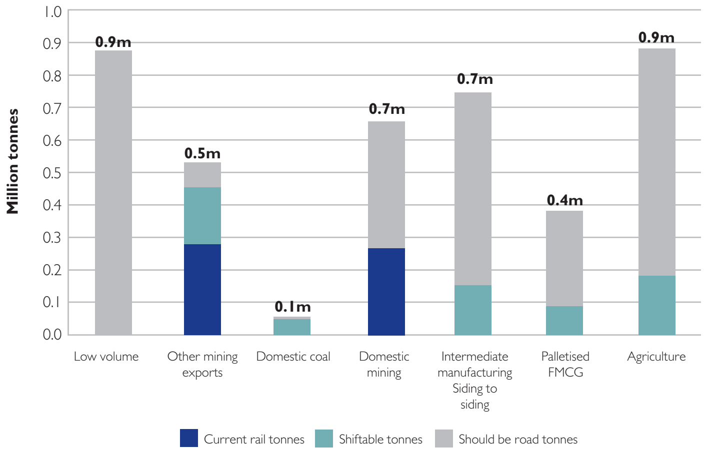


Figure 3: Modal shift opportunity per segment on the N7

Table 5: Modal shift opportunity per segment on the N7

Segment	Road tonnes	Rail tonnes	Shiftable tonnes
Low volume targetable	874 495	-	(0%)
Other mining exports	250 928	280 618	174 015 (69.3%)
Domestic coal	56 172	-	50 503 (89.9%)
Domestic mining	385 281	267 560	(0%)
Intermediate manufacturing - Siding to siding	748 226	-	152 422 (20.4%)
Palletised FMCG	380 622	-	88 081 (23.1%)
Agriculture	881 863	-	182 327 (20.7%)
Total	**3 577 586**	**548 178**	**647 348 (18.1%)**

Transport costs on the N7 corridor are currently 11.5% 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 19.5%, by 2052. If the rail market share remains constant this will increase to 11.2%.

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)
2021- Current market share	1.6	11.5%	0.17	9.1
2027 - Stagnant rail volumes	2.1	14.9%	0.28	14.2
2027 - Constant market share	2.1	13.1%	0.24	13.1
2027 - Growth market share	1.8	-	-	-
2052 - Stagnant rail volumes	4.2	19.5%	0.68	31.3
2052 - Constant market share	3.9	11.2%	0.39	21.1
2052 - Growth market share	3.5	-	-	-

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.

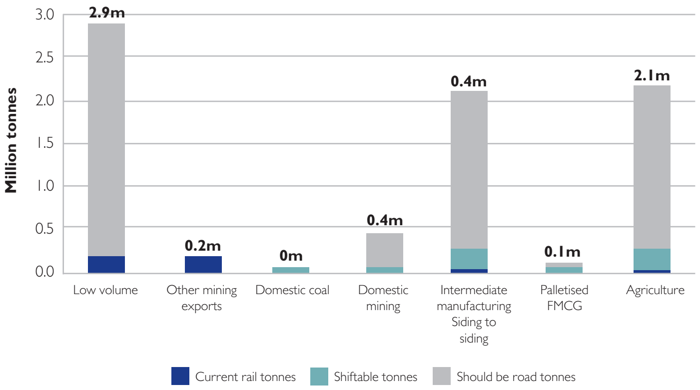


Figure 4: Modal shift opportunity per segment for Western Cape core traffic

Transport costs for the Core Western Cape across all segments are currently 0.7% higher in the absence of modal shift (see Table 8). By 2052 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)
2021 - Current market share	0.63	0.7%	0.00	2.39
2027 - Stagnant rail volumes	1.91	2.7%	0.05	5.30
2027 - Constant market share	1.91	2.6%	0.05	5.26
2027 - Growth market share	1.87			
2052 - Stagnant rail volumes	2.09	1.9%	0.04	6.70
2052 - Constant market share	2.08	1.7%	0.03	6.41
2052 - Growth market share	2.05			

Summary

In 2021 the total transportation bill for freight touching the Western Cape was R63.7bn. The combined effect of the modal shift on the three corridors and core Western Cape traffic would have been a reduction of R5.04 billion or 7.9% in transport costs for the Western Cape (the 2021 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 2018 (Rbn)	% saving on total Western Cape transport bill	CO_2 emission reduction (000' tonnes)
N1	4.77	7.48 %	375.1
N2	0.10	0.16 %	30.0
N7	0.17	0.26 %	9.1
Core Western Cape	0.00	0.01 %	2.39
Total	5.04	7.90%	379.7

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 78.8m tonnes of Western Cape Road freight, a portion of 40.7m 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	22.3	0.2	22.5	7.2 (31.9%)	10.2	4.77
N2 Corridor traffic	4.5	0.0	4.5	1.2 (26%)	0.8	0.10
N7 Corridor traffic	2.7	0.5	3.3	0.6 (19.9%)	0.2	0.17
Metropolitan traffic	2.3	-	2.3	0.2 (8%)	0.01	0.001
Core Western Cape	4.8	0.2	5.0	0.6 (11.8%)	0.1	0.004
Non-Corridor traffic	4.2	0.1	4.3	1.2 (28.8%)	1.6	0.78
Total	**40.7**	**1.1**	**41.8**	**11 (26.3%)**	**13.0**	**5.82**

Highlights

- As rail traffic becomes more dense, it becomes more efficient.
- An estimated 7.9% of the Western Cape's total freight transportation cost could be saved through modal shift at current rail tariffs.
- Increased potential for modal shift cost savings (when compared to the 2020 results) was driven by the increase in freight movement on the N1 and N2, combined with a higher fuel price in 2020.
- 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 7.48% of total transport cost.

Western Cape Freight Demand Model (WC FDM™)
Air freight data

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

The process to obtain air freight data for the purpose of the WC FDM™ posed many challenges. Various avenues were explored to gather domestic air freight data with a similar level of detail to the model's data on other transport modes. The process included extensive desktop research, along with email correspondence and other engagements with numerous stakeholders within the domestic air freight industry, namely representatives of:

- A prominent air freight service company;
- Airports Company South Africa (ACSA) – more specifically, Cape Town International Airport (CTIA);
- Air transport-related industry associations – namely the South African Association of Freight Forwarders (SAAFF) and the World Wide Fund for Nature (WWF) South Africa; and
- The Cape Town Air Access project, a partnership between ACSA, Cape Town Tourism, South African Tourism, Wesgro, the City of Cape Town, and the Western Cape Government.

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 2021, there were 41 665 freight tonnes transported via CTIA, whereof 21 518 tonnes (52%) were exported and 20 147 tonnes (48%) were imported. This shows a growth of 30.5% (9 736 tonnes) from the 2020 volumes of 31 929 tonnes. However, air trade volumes are still much lower than the 63 015 tonnes transported in 2019. While exports still contribute to the majority of air trade, the export-import split has grown closer in 2021. The extent of air freight arriving (import) and departing (export) from CTIA is depicted in Figure 1.

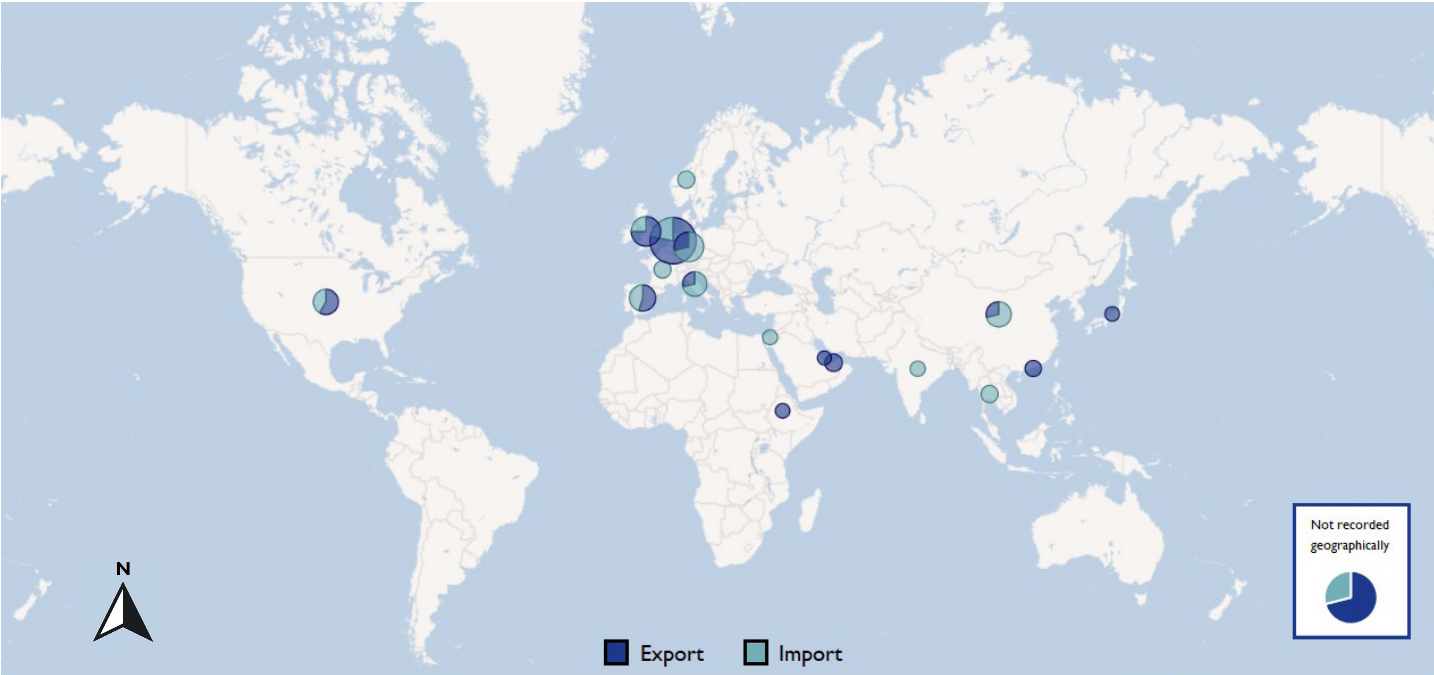


Figure 1: Map showing the import and export freight volumes for Cape Town International Airport in 2021

The top 10 commodities in terms of total volume traded (imports and exports combined) are depicted in Figure 2. Note that the 'other commodities' group shows the combined remaining air freight commodities. The 'Not Else Specified' group refers to volumes that do not include information on the commodity type.

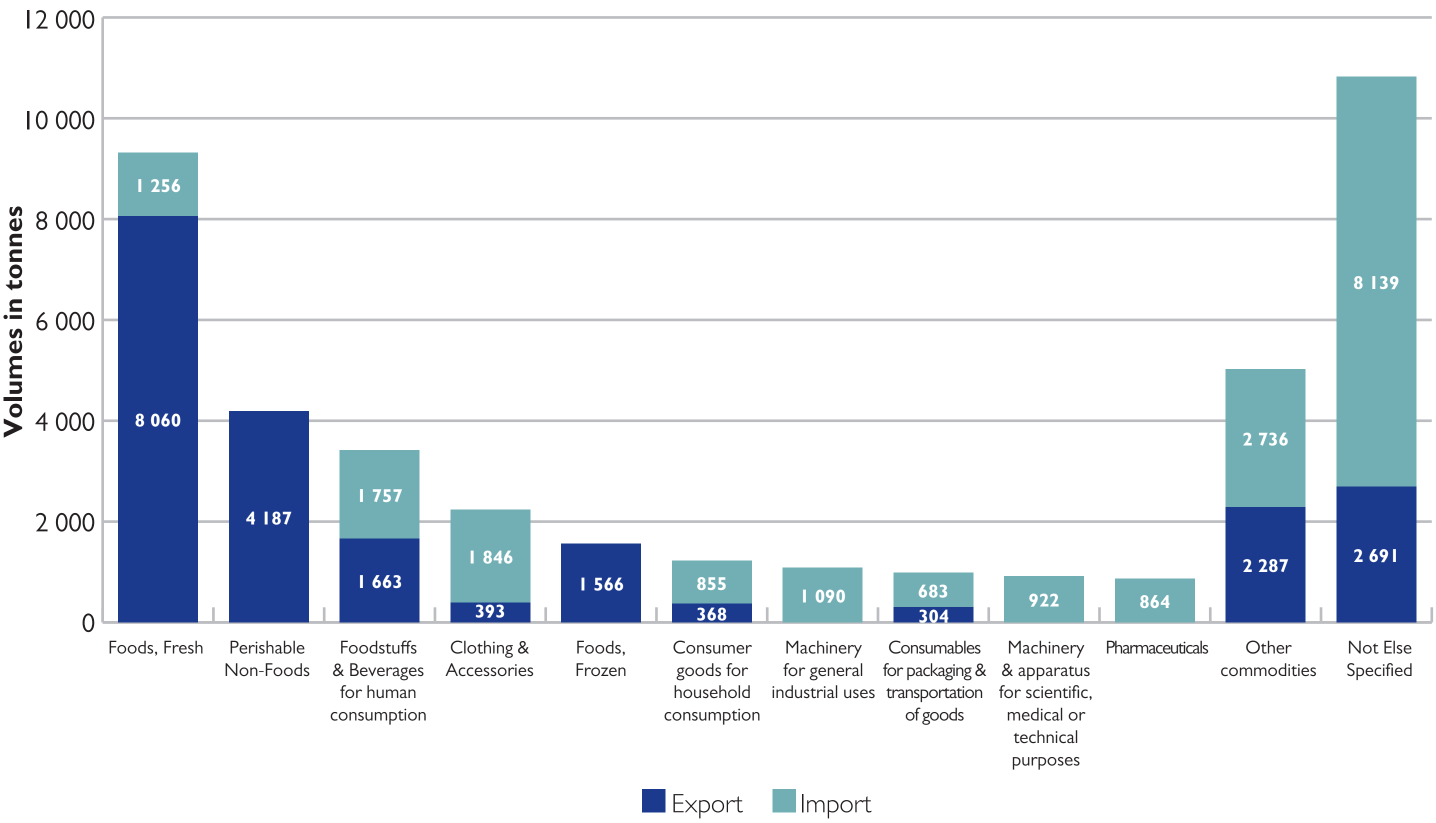


Figure 2: The most significant Cape Town air freight commodities based on trade volumes (exports and imports) in 2021

Tables 1 and 2 below show how the most significant air freight commodities have changed between 2019 and 2021 for exports and imports respectively. Note that some commodities might account for a significant export or import volume, but for a relatively low total trade volume. This explains why a significant export commodity like odours and flavours does not appear in Figure 2, where it's grouped together in 'Other commodities'. Note that 'Not Else Specified' group in Tables 1 and 2 refers to volumes that do not include information on the commodity type.

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 2021 are related to perishable non-foods (4 187 tonnes); clothing and accessories (2 239 tonnes); and consumer goods for household consumption (1 223 tonnes). Interestingly, while their overall trade volumes are relatively high, no perishable non-foods and frozen foods are imported via CTIA. Furthermore, while 2021's export and import volumes are much higher than in 2020, they are still lower than those traded in 2019 (see Tables 1 and 2).

Table 1: The most significant Cape Town air freight commodities between 2019 and 2021 based on export trade volumes

Exports by commodity in tonnes *(% of total exports)*	**2019**	**2020**	**2021**
Food	17 036 *(51.1%)*	9 631 *(55.8%)*	11 289 *(52.5%)*
Foods, Fresh	15 035 *(45.1%)*	8 085 *(46.8%)*	8 060 *(37.5%)*
Foodstuffs & Beverages for human consumption	1 361 *(4.1%)*	882 *(5.1%)*	1 663 *(7.7%)*
Foods, Frozen	641 *(1.9%)*	665 *(3.8%)*	1 566 *(7.3%)*
Perishable Non-Foods	4 173 *(12.5%)*	2 351 *(13.6%)*	4 187 *(19.5%)*
Basic industrial raw materials	716 *(2.1%)*	257 *(1.5%)*	703 *(3.3%)*
Consumer goods for personal consumption	313 *(0.9%)*	226 *(1.3%)*	516 *(2.4%)*
Odours & Flavours	763 *(2.3%)*	312 *(1.8%)*	414 *(1.9%)*
Clothing & Accessories	684 *(2%)*	376 *(2.2%)*	393 *(1.8%)*
Consumer goods for household consumption	447 *(1.3%)*	364 *(2.1%)*	368 *(1.7%)*
Colours & Dyes	458 *(1.4%)*	835 *(4.8%)*	356 *(1.7%)*
Consumables for packaging & transportation of goods	307 *(0.9%)*	80 *(0.5%)*	304 *(1.4%)*
Consumables for the leather & fur industry	961 *(2.9%)*	295 *(1.7%)*	297 *(1.4%)*
Not Else Specified	7 495 *(22.5%)*	2 543 *(14.7%)*	2 691 *(12.5%)*
Total exports	**33 353**	**17 269**	**21 518**

Table 2: The most significant Cape Town air freight commodities between 2019 and 2021 based on import trade volumes

Imports by commodity in tonnes *(% of total imports)*	**2019**	**2020**	**2021**
Food	3 885 *(13.1%)*	1 656 *(11.3%)*	3 013 *(15%)*
Foods, Fresh	2 337 *(7.9%)*	814 *(5.6%)*	1 256 *(6.2%)*
Foodstuffs & Beverages for human consumption	1 548 *(5.2%)*	842 *(5.7%)*	1 757 *(8.7%)*
Clothing & Accessories	4 981 *(16.8%)*	1 604 *(10.9%)*	1 846 *(9.2%)*
Machinery for general industrial uses	931 (3.1%)	577 *(3.9%)*	1 090 *(5.4%)*
Machinery & apparatus for scientific, medical or technical purposes	698 *(2.4%)*	656 *(4.5%)*	922 *(4.6%)*
Pharmaceuticals	677 *(2.3%)*	439 *(3%)*	864 *(4.3%)*
Consumer goods for household consumption	1 085 *(3.7%)*	491 *(3.3%)*	855 *(4.2%)*
Semi-manufactured industrial consumables	1 065 *(3.6%)*	481 *(3.3%)*	724 *(3.6%)*
Semiconductors	1 634 *(5.5%)*	1 665 *(11.4%)*	700 *(3.5%)*
Other chemicals & products	862 *(2.9%)*	382 *(2.6%)*	685 *(3.4%)*
Consumables for packaging & transportation of goods	554 *(1.9%)*	576 *(3.9%)*	683 *(3.4%)*
Plastic & rubber industrial consumables	1 128 *(3.8%)*	604 *(4.1%)*	627 *(3.1%)*
Not Else Specified	12 161 *(41%)*	5 530 *(37.7%)*	8 139 *(40.4%)*
Total exports	**29 661**	**14 660**	**20 147**

The major air freight trading partners facilitated by Cape Town International Airport in terms of the import and export freight volumes for 2021 is depicted in Figure 3.

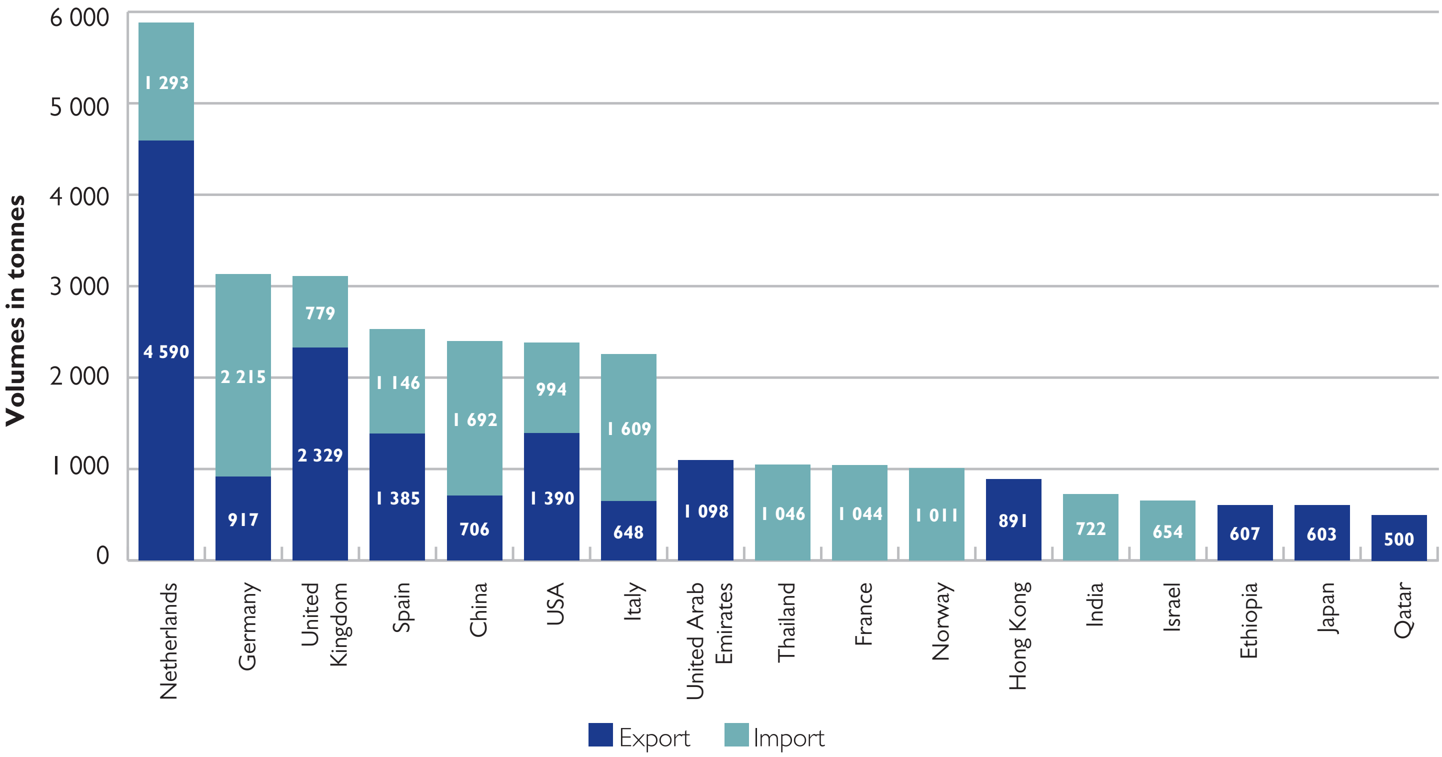


Figure 3: Import and export freight volumes for the major air freight trading partners facilitated by Cape Town International Airport in 2021

As seen in Table 3, the largest trading partners for export air freight were the Netherlands and the United Kingdom, but with significant changes in this dynamic since 2020. Export volumes to the Netherlands increased by more than 50% (1 540 tonnes), yet remain slightly lower than those achieved in 2019. In comparison, exports to the UK decreased by approximately 30% (949 tonnes). It is, therefore, not surprising that the UK has been surpassed as CTIA's most significant export air trade destination.

Table 3: The most significant Cape Town air freight trading partners between 2019 and 2021 based on export trade volumes

Export partner *(% of total exports)*	**2019**	**2020**	**2021**
Netherlands	4 665 *(14%)*	3 050 *(17.7%)*	4 590 *(21.3%)*
United Kingdom	6 088 *(18.3%)*	3 278 *(19%)*	2 329 *(10.8%)*
USA	3 305 *(9.9%)*	1 025 *(5.9%)*	1 390 *(6.5%)*
Spain	1 300 *(3.9%)*	830 *(4.8%)*	1 385 *(6.4%)*
United Arab Emirates	1 050 *(3.1%)*	576 *(3.3%)*	1 098 *(5.1%)*
Germany	1 143 *(3.4%)*	821 *(4.8%)*	917 *(4.3%)*
Hong Kong	1 379 *(4.1%)*	1 057 *(6.1%)*	891 *(4.1%)*
China	1 078 *(3.2%)*	745 *(4.3%)*	706 *(3.3%)*
Italy	644 *(1.9%)*	338 *(2%)*	648 *(3%)*
Ethiopia	395 *(1.2%)*	216 *(1.3%)*	607 *(2.8%)*
Japan	901 *(2.7%)*	282 *(1.6%)*	603 *(2.8%)*
Qatar	169 *(0.5%)*	126 *(0.7%)*	500 *(2.3%)*

The most significant import trading partners remained fairly the same between 2019 and 2021 (see Table 4). However, import trade volumes from Italy were the third highest in 2021 while the country was not a prominent trade partner in the year before. The import volumes from Italy in 2021 were also higher than in 2019, which is a significant departure from the overall trend of decreased import volumes compared to 2019.

Table 4: The most significant Cape Town air freight trading partners between 2019 and 2021 based on import trade volumes

Import partner *(% of total imports)*	**2019**	**2020**	**2021**
Germany	2 602 *(8.8%)*	1 468 *(10%)*	2 215 *(11%)*
China	1 964 *(6.6%)*	1 213 *(8.3%)*	1 692 *(8.4%)*
Italy	1 540 *(5.2%)*	722 *(4.9%)*	1 609 *(8%)*
Netherlands	1 572 *(5.3%)*	779 *(5.3%)*	1 293 *(6.4%)*
Spain	1 547 *(5.2%)*	815 *(5.6%)*	1 146 *(5.7%)*
Thailand	1 194 *(4%)*	944 *(6.4%)*	1 046 *(5.2%)*
France	1 286 *(4.3%)*	694 *(4.7%)*	1 044 *(5.2%)*
Norway	1 410 *(4.8%)*	605 *(4.1%)*	1 011 *(5%)*
USA	1 489 *(5%)*	640 *(4.4%)*	994 *(4.9%)*
United Kingdom	1 219 *(4.1%)*	618 *(4.2%)*	779 *(3.9%)*
India	1 117 *(3.8%)*	549 *(3.7%)*	722 *(3.6%)*
Israel	554 *(1.9%)*	354 *(2.4%)*	654 *(3.2%)*

As seen in Table 5, CTIA's largest air freight food trade partners in 2021 are the Netherlands, the UK, and Spain. In the previous year, this was the same except Hong Kong was the third largest food trade partner instead of Spain and the UK was a more significant trading partner than the Netherlands.

Table 5: The most significant Cape Town air freight trading partners between 2019 and 2021 based on food trade volumes

Food trade partner *(% of total food trade)*	**2019**	**2020**	**2021**
Netherlands	2 163 *(10.3%)*	1 471 *(13%)*	1 982 *(13.9%)*
United Kingdom	5 360 *(25.6%)*	2 729 *(24.2%)*	1 813 *(12.7%)*
Spain	1 172 *(5.6%)*	714 *(6.3%)*	1 681 *(11.8%)*
Norway	1 381 *(6.6%)*	570 *(5.1%)*	980 *(6.9%)*
United Arab Emirates	832 *(4%)*	449 *(4%)*	934 *(6.5%)*
Hong Kong	1 319 *(6.3%)*	1020 *(9%)*	846 *(5.9%)*
Ethiopia	386 *(1.8%)*	207 *(1.8%)*	599 *(4.2%)*
Italy	682 *(3.3%)*	301 *(2.7%)*	591 *(4.1%)*
China	629 *(3%)*	522 *(4.6%)*	585 *(4.1%)*
Germany	410 *(2%)*	253 *(2.2%)*	521 *(3.6%)*
Qatar	150 *(0.7%)*	121 *(1.1%)*	488 *(3.4%)*
USA	250 *(1.2%)*	105 *(0.9%)*	182 *(1.3%)*
France	288 *(1.4%)*	88 *(0.8%)*	122 *(0.9%)*
Japan	298 *(1.4%)*	55 *(0.5%)*	64 *(0.4%)*
India	17 *(0.1%)*	16 *(0.1%)*	37 *(0.3%)*
Israel	7 *(0%)*	12 *(0.1%)*	9 *(0.1%)*

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 2021,
- WC FDM™ 2017 – 2021,
- 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 FDM™ data.

The data processing methodology for the three WC FDM™ waste streams for the CoCT is discussed below. Apart from the CoCT, there are 24 other municipalities within the Western Cape that are served by 61 waste facilities, (as can be seen in Figure 1), that report handling municipal, green, and construction and demolition waste. The forecast that was used for the CoCT municipal waste assignments was also applied to WC FDM™ districts.

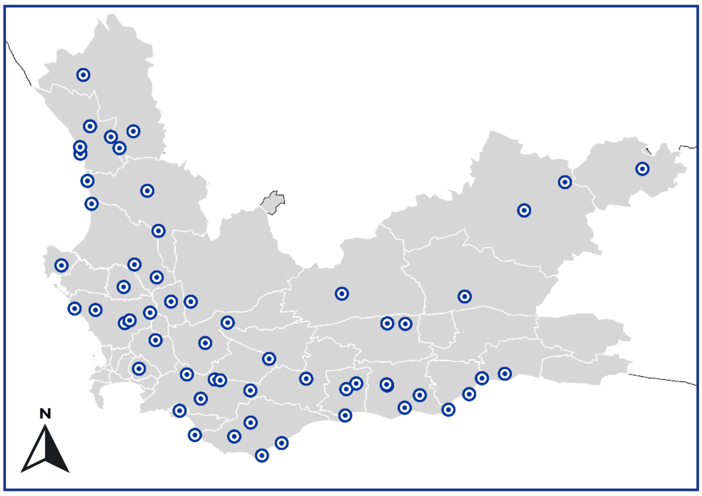


Figure 1: Provincial waste facilities, excluding those of the CoCT.

[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.

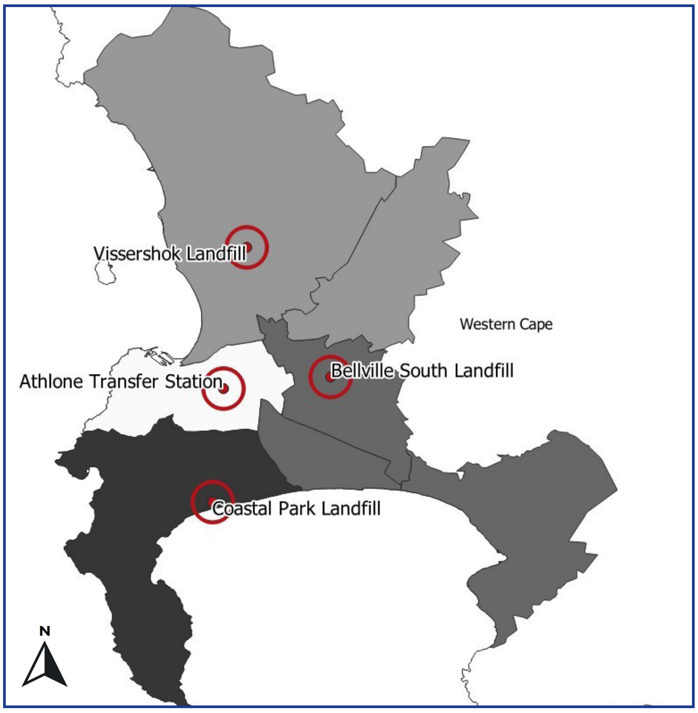


Figure 2: Catchment areas for the various refuse transfer stations and landfills in the CoCT Municipality.

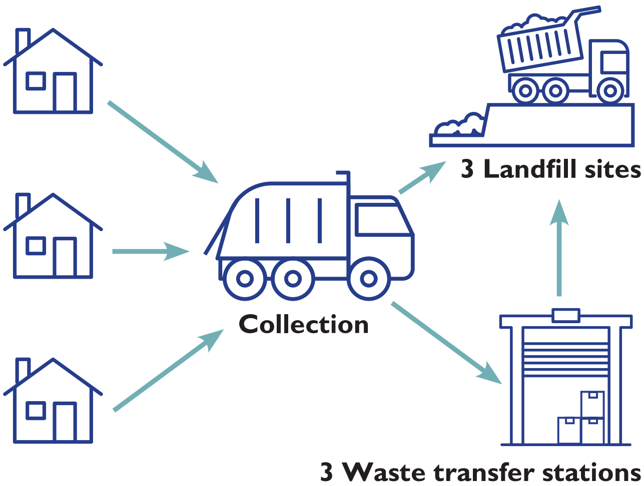


Figure 3: The waste collection and transfer process

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.

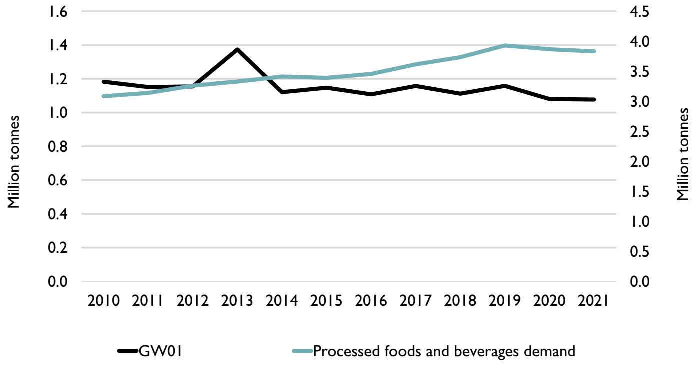


Figure 4: Municipal waste generation (left axis) and demand for processed foods and beverages (right axis) in CoCT Municipality 2010-2021.

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 is therefore subject to consumer behaviours regarding food waste and recycling, which 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.

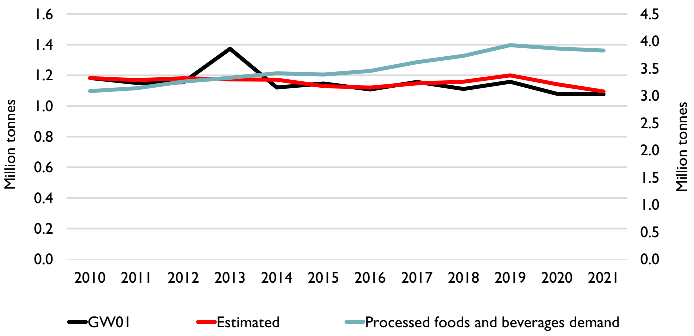


Figure 5: Municipal waste generation and estimated waste generation assuming an accumulating 34 000 tonnes per year offset (left axis) and demand for processed foods and beverages (right axis) in CoCT Municipality 2010-2021.

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 28.1% for future years which leads to the municipal waste forecast for the CoCT as can be seen in Figure 6.

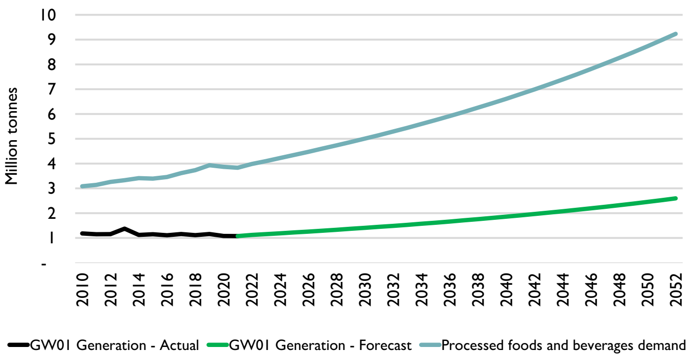


Figure 6: Processed foods and beverages demand for the CoCT and GW01 waste generation forecast.

Even though there is a definite disconnect between urban and rural municipal waste generation, the CoCT municipal forecast of 28.1% of processed foods and beverages is used to grow the 2021 all 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		
	2021	2022	2027	2052
CoCT	1.08	1.12	1.29	2.59
Rest of Province	0.31	0.32	0.38	0.75
Total	1.39	1.44	1.67	3.34

Given that there is no additional reduction at source or recycling uptake by consumers, municipal waste is forecast to increase 2.4 times by 2052, based on the forecast processed foods and beverage demand of the Western Cape.

2. GW20.01 – Green 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"). Most of this waste is GW20.01 (green waste) that is separated at source (e.g. by being dropped off at drop-off points). Some of this green 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 green 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 green 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 green waste generation was caused partly by the drought that started in 2015 and continued until 2018. The increase in green 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.

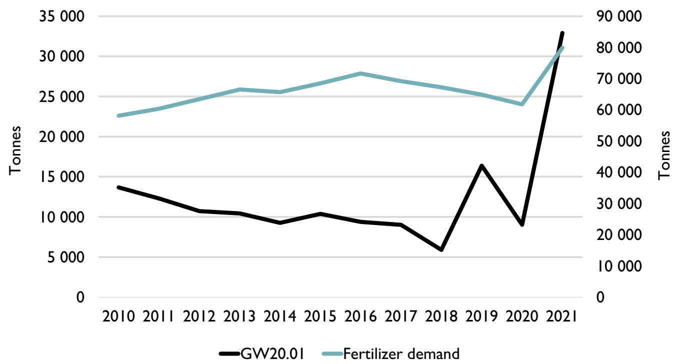


Figure 7: Green waste generation (left axis) and fertilizer demand (right axis) for the CoCT.

As lockdown restrictions were eased garden maintenance once again resumed which led to the increase or 'over recovery' in green waste generation. The expectation is that this steep trend will not continue past 2021.

To forecast the green 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 191kg of green waste is generated. The model had an R^2 of 0.81 with a p-value of (0.00003) which indicates that there is statistical plausibility between the demand for fertilizer and the generation of green waste for the period 2010-2021. A more 'statistically significant' fit could be found if only the regression was based on the values up until 2019. This would not take into account the build-up of potential green waste and be slightly underrepresenting the rate at which green waste would be generated in a non-drought environment. The estimated green waste generation can be seen in Figure 8.

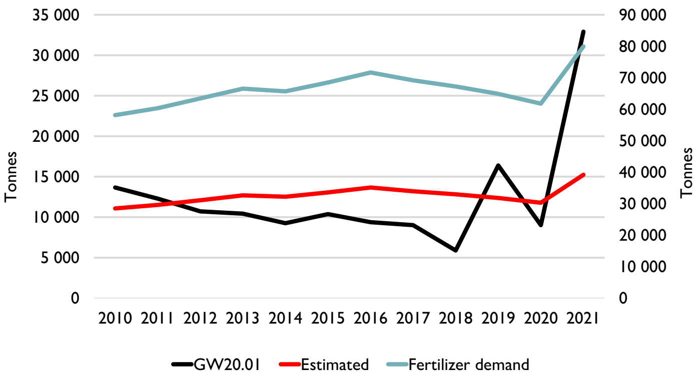


Figure 8: Green waste generation and estimated waste generation (left axis) and fertilizer demand (right axis) for the CoCT.

Due to the nature of how green 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 green waste generated to the cumulative demand for fertilizer from 2010 to 2021. That is the sum of green waste divided by the sum of fertilizer demand for the CoCT, which comes to 187 kg of green waste generation per tonne of fertilizer demand. This highlights the plausibility of using a simplified material flow approach for forecasting durable waste such as green waste as well as construction and demolition waste. However, due to its statistical significance, the 191 kg was used for the forecasting of provincial green waste as can be seen in Figure 9.

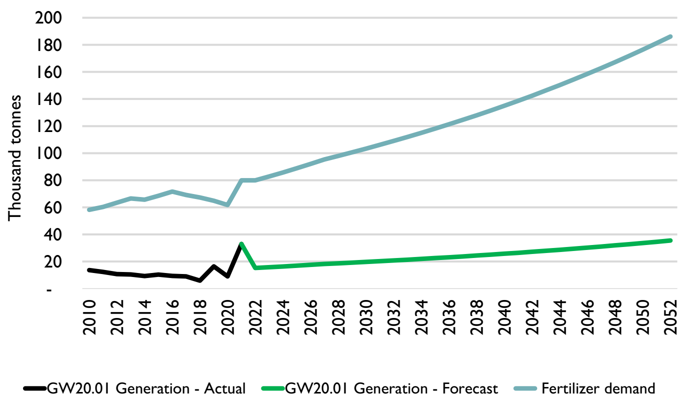


Figure 9: Fertilizer demand for the CoCT and GW20.01 waste generation forecast.

Green waste was forecast on the same principle as municipal waste: The rate of change between 2021 and 2022, 2027 and 2052 based on the forecast of fertilizer demand was applied to all green waste generation within the province as can be seen in Table 2.

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

	Actual	Forecast		
Origin	2021	2022	2027	2052
CoCT	0.03	0.02	0.04	0.06
Rest of Province	0.12	0.06	0.14	0.24
Total	0.15	0.07	0.18	0.30

Based on the forecast demand for fertilizer the total amount of green waste generation is set to double by 2052.

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.

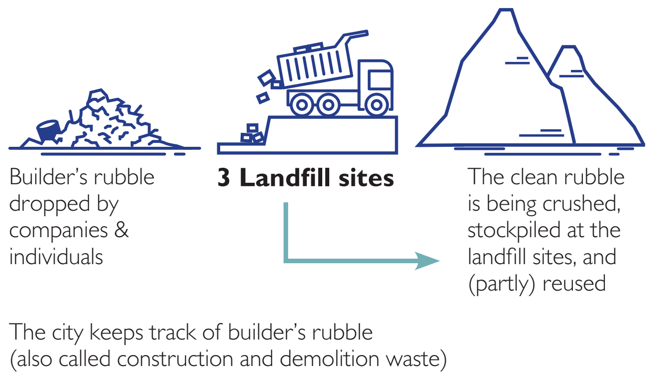


Figure 10: GW30 – Construction and demolition waste.

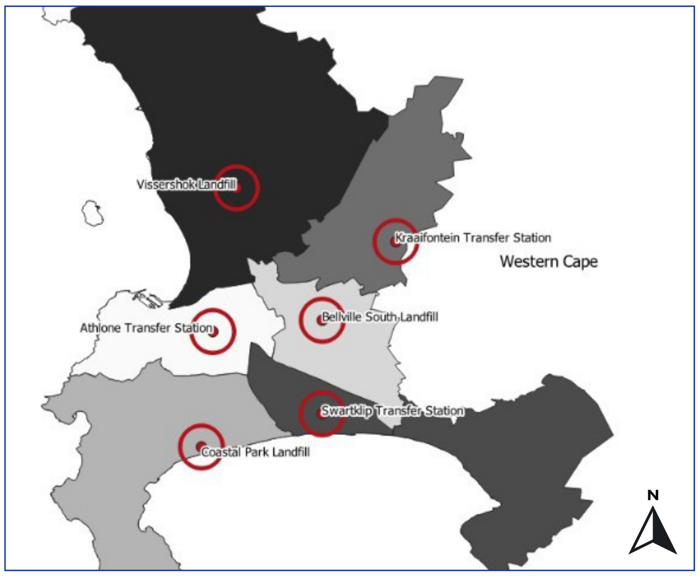


Figure 11: Catchment areas of industrial builder's rubble flow dropped off directly at landfill sites. This can come from anywhere in Cape Town, and it could go to any of the three landfill sites where it is stockpiled.

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 green waste generation is dependent 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.

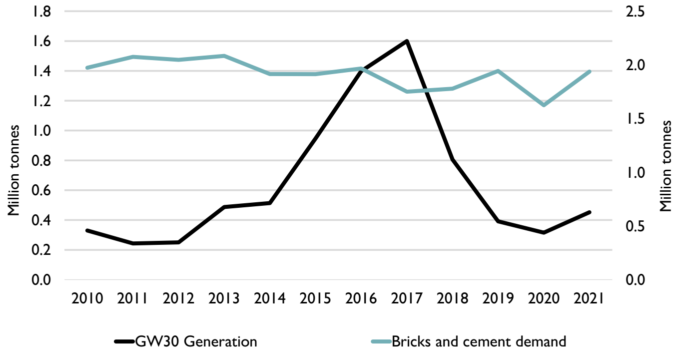


Figure 12: Construction and demolition waste generation (left axis) and the demand for bricks and cement (right axis) in the CoCT.

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 2010-2021. 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 336 kg of construction and demolition waste is generated, as can be seen in Figure 13.

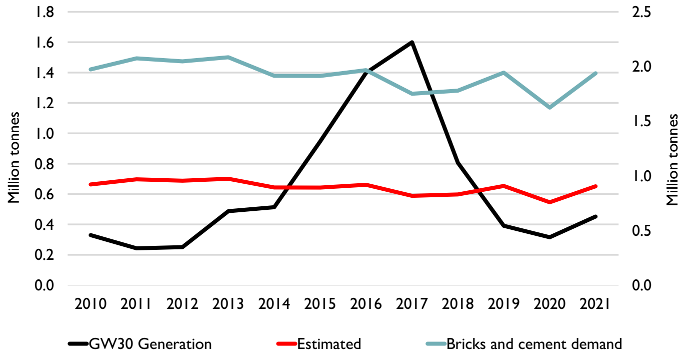


Figure 13: Construction and demolition waste generation and estimated generation (left axis) and the demand for bricks and cement (right axis) in the CoCT.

The rate of change from 2021 to 2022, 2027 and 2052, 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.

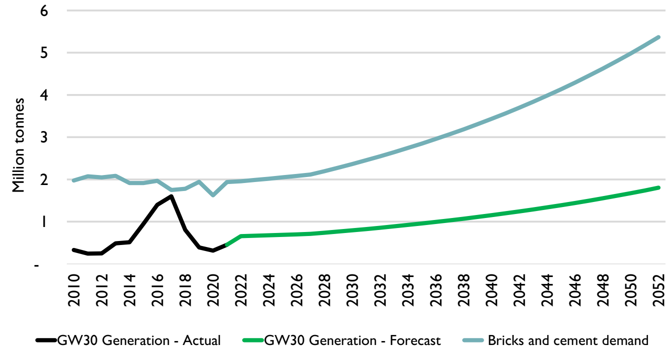


Figure 14: Bricks and cement demand for the CoCT and GW30 waste generation forecast.

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 2.5 times by 2052.

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

Origin	2021	2022	2027	2052
CoCT	0.45	0.66	0.49	1.15
Rest of Province	0.22	0.32	0.24	0.56
Total	0.67	0.98	0.73	1.70

Highlights

- Municipal waste reduction initiatives have seemingly been reducing the waste generation cumulatively by 34 000 tonnes per year since 2010, 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.
- Green waste generation is expected to double by 2052 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.