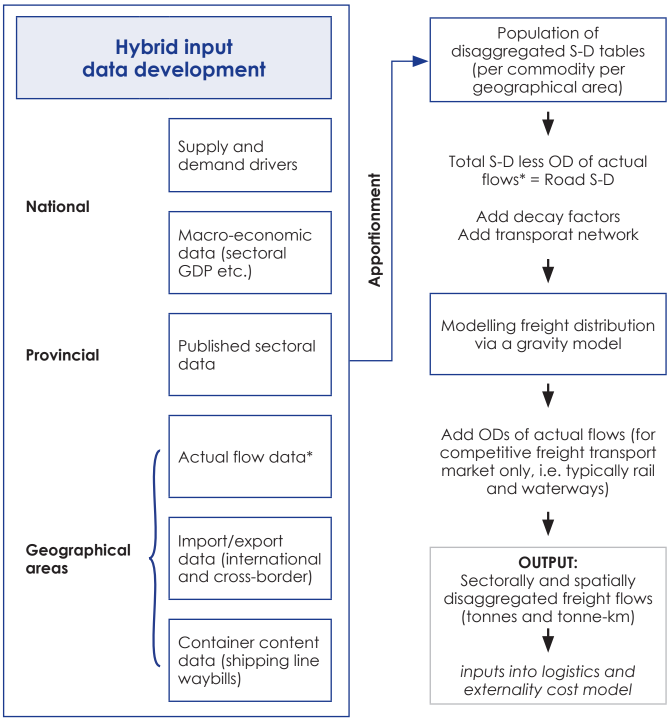
The process and key data sources that are used to develop the Western Cape Freight Demand Model[1] are indicated in Figure 1. The model produces supply and demand data which, in turn, defines freight flows in terms of origin, destination, commodity, volume and transport mode. The primary steps include: 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). Supply-and-demand tables are developed based on a hybrid approach that utilises the available datasets for each geography.



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

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

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

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

Econometric modelling

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

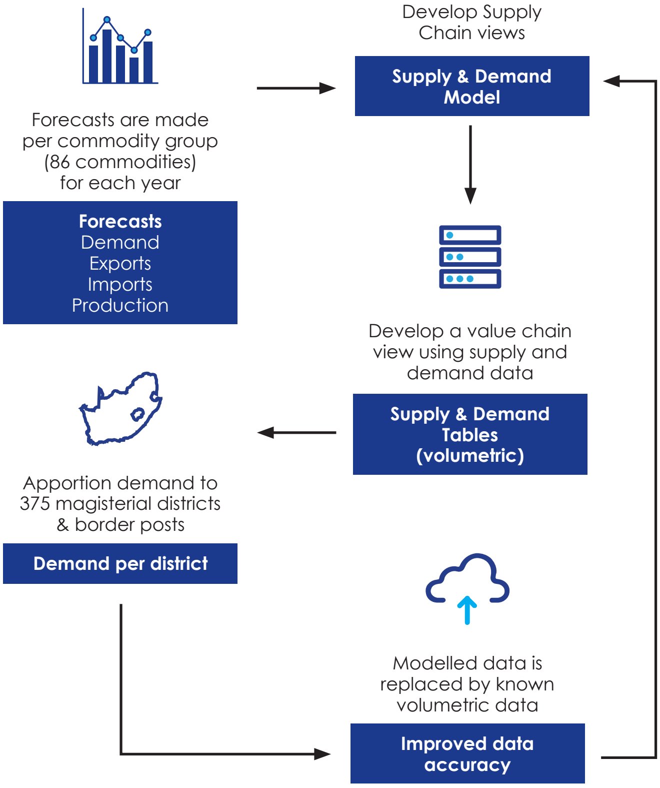


Figure 2: Econometric model

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

Flow modelling

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

The input data is created by subtracting the volume of known flows per geographical district (rail, pipeline, conveyor) from the total supply and demand volumes.

[1] Western Cape Freight Demand Model utilises in part the "FDM" (a registered trademark of GAIN Group (Pty) Ltd)

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.

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). 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.

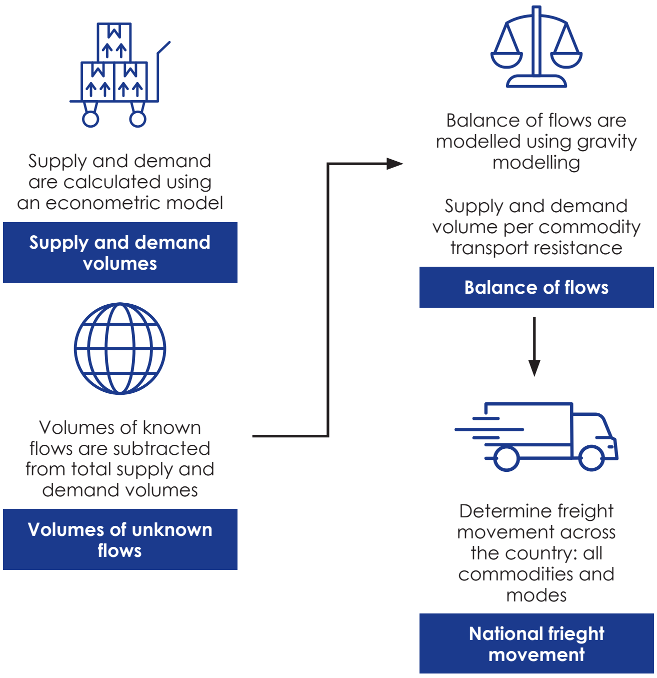


Figure 3: Flow Model

The Western Cape Freight Demand Model (WC FDM™)

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

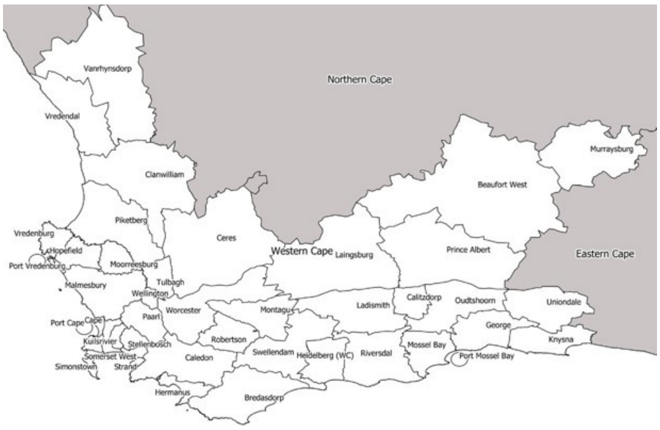


Figure 4: Geographical districts within the Western Cape

Data sources

During the development of the WC FDM™, the following data sources were used:

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

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

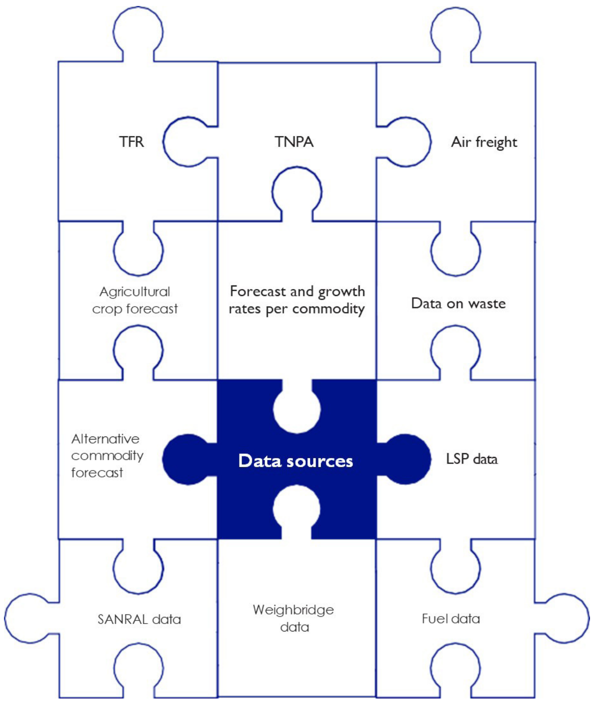


Figure 5: Data Sources

[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.

1. Forecasts and growth rates: Revised in line with the national FDM™ for imports, exports, production, intermediate demand and final demand/consumption in WC FDM™.
2. Waste: Data collected and included in the model.
3. Participating Logistics Service Providers (LSPs): 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: International air freight handled by Cape Town International Airport included but not yet integrated with other modes of transport in the FDM™, as the origin destination (OD) detail is not available.

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

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

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

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

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