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## Low Carbon Frameworks: Transport

PHOTO: ELSABE GELDERBLOM



# UNDERSTANDING FREIGHT EMISSIONS

WWF's low-carbon frameworks transport project explores the implications of carbon emission reduction strategies in the freight transport sector.

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## Introduction

The first task in the freight transport study was to find out where the majority of emissions originate in South Africa, based on available data. The data for this study included:

- Freight activity (how much of each commodity type is transported through each mode: rail, road, domestic maritime and air transport); and
- Greenhouse gas emissions per mode.

By analysing this data and considering the freight mitigation opportunities and interventions that are available and applicable to each mode, as well as to the transport typologies and commodities (this work is underway), the study allows us to select a target commodity for detailed modelling in future work.

## Freight activity data

Publicly available data and statistics relating to overland-freight movement (road and rail) within South Africa is limited (see Appendix A).

The best source for estimates of national freight movement is based on the outputs of:

- The National Freight Flow Model (NFFM); and
- The Freight Demand Model (FDM).

These models were developed by the Centre for Supply Chain Management at the Department of Logistics at Stellenbosch University in response to the lack of freight activity data in South Africa (Havenga J. , 2007). The models draw on economic input-output tables, traffic-count data from the South African National Roads Agency (SANRAL) and rail-freight data from Transnet. They estimate freight flows across all modes through gravity modelling for 74 commodity groupings in 356 magisterial districts (van Eeden and Havenga).

The FDM separates road and rail freight into the following categories or transport typologies:

- **Primary:** the bulk transport of primary commodities by rail for export;
- **Corridor:** rail and road traffic along the main transport links between cities (for example, the Cape Town - Johannesburg link on the N1);
- **Rural:** traffic within the rural areas of provinces (excluding Gauteng) that feeds into the corridor and metropolitan networks; and
- **Metropolitan:** traffic within cities.

The characteristics of these typologies are described below:

### Characteristics of transport typologies

Characteristic	Primary	Corridor	Rural	Metropolitan
Type of freight	Bulk low-value commodities (such as export coal and iron ore)	Mostly manufacturing and some agriculture	Mostly agriculture	Mostly final delivery
Distance	Long distance	Long and short distance	Medium and short distance	Short distance
Origin-Destination (OD) pairs*	Few and one-directional	Few long-distance ODs, many ODs at end points	Many	Many

Data source: Havenga and Pienaar, 2012)

\* An Origin-Destination pair is a specified point of pick up and point of delivery for freight.

PHOTO: ELISABETH GELDERLOM



The percentage contribution to overall transport emissions by road freight is 93.1%.

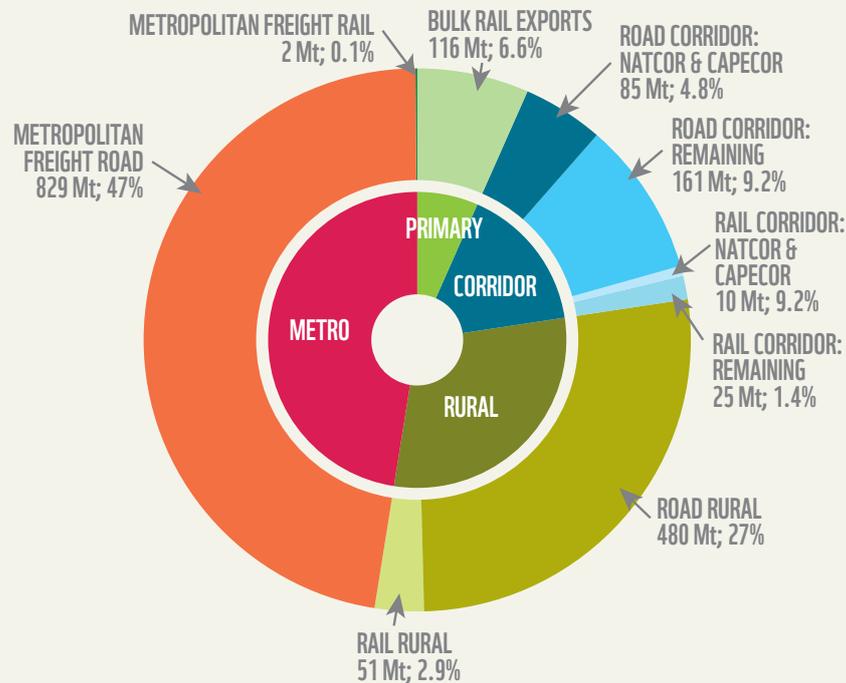
**40%**  
CORRIDOR FREIGHT  
TRANSPORT  
ACCOUNTED FOR  
ALMOST 40% OF THE  
TOTAL FREIGHT FLOW  
IN 2012

The outputs of the NFFM and FDM underpin the figures published in the annual State of Logistics Surveys (CSIR, 2013). These surveys present the aggregated, modelled road and rail freight flows for the country (CSIR, 2013). Transnet and the Department of Transport also have access to the model results, as well as 30-year forecasts.

We summarise the total freight flow reported for 2012 in the 9th State of Logistics Report respectively in mega-tonne (Mt) and tonne-km (t-km) within each of the typologies, in Figures 1 and 2. Note the following:

- While a large tonnage of freight is transported on metropolitan networks (47%), the contribution to freight activity in terms of tonne kilometres is low, at just 15%, because of the short distances involved.
- Corridor freight only accounts for 16% of total tonnages transported, but because of the long distances associated with corridor transport, it accounts for almost 40% of all freight tonne kilometres.
- The long distances associated with the transport of bulk rail exports to markets means that similar trends are observed for this category.
- Rural freight is transported over short to medium distances and makes up approximately 30% of freight tonnages and 27% of freight tonne kilometres.

*Figure 1 Breakdown of freight volumes in Mt by typology and mode in 2012*



Data source: CSIR (9th Annual State of Logistics Survey, 2013)

# 39.4 MT CO<sub>2</sub>E

## SOUTH AFRICA'S GHG INVENTORY FROM ENERGY USED IN TRANSPORT IN 2000

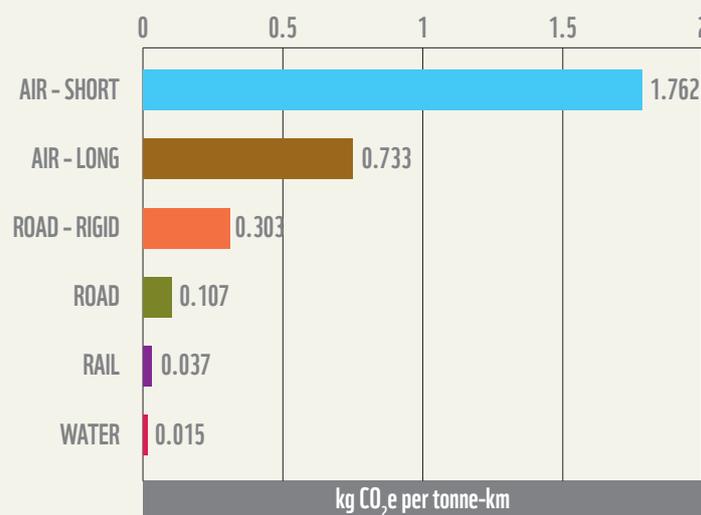
### Freight energy and emissions data

As with freight activity data, disaggregated freight energy and emissions data is not readily available. The available aggregated freight emissions data are presented below, along with the estimated disaggregated emissions from the FDM.

### Freight emissions intensity

The emissions intensity of freight transport differs significantly between transport modes, with air freight being the most emissions intensive, followed by road and then rail. The lowest freight emissions are associated with shipping.

Figure 2 Typical freight emission intensities per mode



### National GHG inventory – 2000 data

South Africa's latest official greenhouse gas (GHG) inventory<sup>1</sup>, published in 2009 but reflecting data from 2000, indicates total emissions of 39.4 Mt CO<sub>2</sub>e from energy used in transport in that year. The inventory provides some disaggregation of these emissions into different modes of transport (as shown the table that follows). However, it does not distinguish between freight and passenger transport. Furthermore, these figures only include emissions from diesel and petrol consumption for road transport, diesel for rail transport, and an estimate of emissions from domestic aviation. Use of electricity (primarily for rail) is not included. The updated national GHG inventory is anticipated to disaggregate passenger and freight emissions.

<sup>1</sup> It is noted that the Department of Environment is currently busy with an update of the inventory using 2007 data, but this has not yet been officially released.



PHOTO: WIKIMEDIA COMMONS

Maria Ramos, former CEO of Transnet, welcomes research and on-going data collection in the field of rail freight

### Contribution of different modes of transport to emissions in 2000

Mode and energy carrier	Greenhouse gas emissions [kt CO <sub>2</sub> e]	Percentage contribution to overall transport emissions
Domestic aviation (kerosene and aviation gas)	2,033	5.2%
Road (petrol)	25,026	63.5%
Road (diesel)	11,666	29.6%
Road (LPG)	3	0%
Rail (diesel only)	688	1.7%
<b>TOTAL</b>	<b>39,416</b>	<b>100%</b>

Data source: (DEA, 2009)

### Transnet GHG emissions

Transnet's 2012 sustainability report provides a breakdown of greenhouse gas emissions by activity. The direct fuel-related emissions and indirect electricity-related emissions of Transnet Freight Rail were 445 kt CO<sub>2</sub>e and 2,803 kt CO<sub>2</sub>e, respectively, which, by comparison with the figures presented above confirms that rail freight is a much smaller source of GHG emissions than road freight.

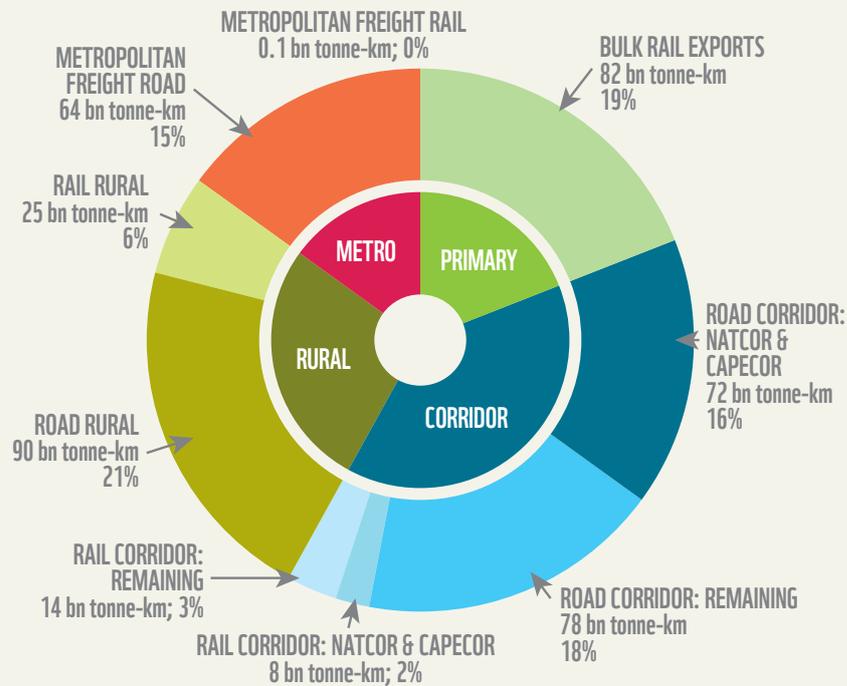
### Emissions per typology from FDM results

The FDM's freight movements per typology (presented in Figure 2) can be converted to greenhouse gas emissions, using the following average emission factors for rail and road, respectively: 0.022 kg/tonne-km and 0.11 kg/tonne-km (Transnet, 2012). The resulting breakdown of freight GHG emissions is shown in Figure 3.

It should be noted that by using average emission factors, these results are indicative only. Therefore, only the percentage split is presented in the figure, rather than absolute values. Contrasting this pie chart with Figure 2, it is clear that road freight is far more emissions-intensive than rail, with rail only accounting for 8% of freight emissions despite accounting for 30% of freight activity. Emissions from road freight dominate, as expected, with road freight along corridors contributing 46% of freight emissions. This is followed by rural road freight, which accounts for close to 30% of freight emissions, and metropolitan road freight, which accounts for almost 20% of freight emissions.

**RAIL  
FREIGHT**  
IS A MUCH SMALLER  
SOURCE OF GHG  
EMISSIONS THAN  
ROAD FREIGHT

**Figure 3 Breakdown of freight GHG emissions by typology and mode in 2012**



Off-loading fish at a supermarket in Cape Town.

## An indication of freight emissions per commodity grouping

Based on the disaggregated data from the FDM and aggregated emission factors for road freight transport, it is possible to estimate road freight emissions associated with each of the various commodity groupings. The complete output of the FDM was not available at the time of writing. Therefore, a limited data set of earlier model data for 2008, provided by van Eeden and Havenga (Identification of key target markets for intermodal freight transport solutions in South Africa, 2010), was used for demonstration. We do not anticipate that the results will be significantly different to more recent years. The data and analysis provided by van Eeden and Havenga (Identification of key target markets for intermodal freight transport solutions in South Africa, 2010) identified the top 12 commodity groups on the Durban-Gauteng corridor, the Cape Town-Gauteng corridor and the remaining corridors in terms of tonne-kilometres, together with the current rail-market share. To obtain the road emissions, the tonne-kilometres were adjusted for rail-market share and converted to indicative GHG emissions, using the emission factors described above. This provides the following estimate of the breakdown of emissions per commodity type on the Durban-Gauteng, Cape Town-Gauteng and remaining South African road corridors in 2008.

### Durban-Gauteng road corridor freight GHG emissions breakdown by commodity type

Commodity type	Durban-Gauteng corridor freight activity 2008 (billion tonne-km)	Rail market share	Road GHG emissions (Mt CO <sub>e</sub> )	% contribution of commodity to road GHG emissions
Processed foods	4.00	2%	429	20%
Fuel and petroleum products	4.10	6%	422	20%
Beverages	1.40	1%	152	7%
Other chemicals	1.20	2%	129	6%
Paper and paper products	0.80	3%	85	4%
Iron and steel	1.00	23%	84	4%
Wood and wood products	0.80	7%	81	4%
Industrial chemicals	0.70	27%	56	3%
Non-metallic mineral products	0.50	2%	54	3%
Machinery and equipment	0.30	0%	33	2%
Wheat	0.40	37%	28	1%
Coal	0.90	99%	1	0%
Other commodities	6.00	12%	578	27%
			<b>2,132</b>	100%

Data source: van Eeden and Havenga (Identification of key target markets for intermodal freight transport solutions in South Africa, 2010)

### Cape Town-Gauteng road corridor freight GHG emissions breakdown by commodity type

Commodity type	Cape Town-Gauteng corridor freight activity 2008 (billion tonne-km)	Rail market share	Road GHG emissions (Mt CO <sub>e</sub> )	% contribution of commodity to road GHG emissions
Processed foods	8.10	0.00%	887	23%
Beverages	3.40	6.00%	350	9%
Other mining	3.20	0.00%	350	9%
Coal	3.50	11.00%	341	9%
Other chemicals	2.20	2.00%	236	6%
Non-metallic mineral products	1.60	3.00%	170	4%
Fertiliser	1.50	0.00%	164	4%
Wood and wood products	1.30	0.00%	142	4%
Fuel and petroleum products	1.30	1.00%	141	4%
Iron and steel	0.90	3.00%	96	2%
Other agriculture	0.80	0.00%	88	2%
Paper and paper products	0.70	2.00%	75	2%
Other commodities	7.80	5.00%	811	21%
			<b>3,852</b>	100%

Data source: van Eeden and Havenga (Identification of key target markets for intermodal freight transport solutions in South Africa, 2010)



PHOTO: ELSABE GELDERBLOM

The commodity group with the highest freight carbon footprint on all three of the road corridors considered is processed foods, followed by other mining, beverages, other chemicals, and wood and wood products.

### Remaining road corridor freight GHG emissions breakdown by commodity type

Commodity type	Remaining corridor freight activity 2008 (billion tonne-km)	Rail market share	Road GHG emissions (Mt CO <sub>e</sub> )	% contribution of commodity to road GHG emissions
Processed foods	12.30	1%	1,333	20%
Other mining	6.50	0%	712	11%
Beverages	4.50	2%	483	7%
Limestone	4.00	8%	403	6%
Fuel and petroleum products	4.10	12%	395	6%
Other chemicals	3.40	1%	369	6%
Wood and wood products	3.50	23%	295	4%
Non-metallic mineral products	2.50	27%	200	3%
Cement	2.60	34%	188	3%
Other non-ferrous metal mining	1.60	0%	175	3%
Industrial chemicals	1.50	19%	133	2%
Coal	3.30	89%	40	1%
Other commodities	20.20	16%	1,858	28%
			<b>6,583</b>	<b>100%</b>

Data source: van Eeden and Havenga (Identification of key target markets for intermodal freight transport solutions in South Africa, 2010)

This analysis suggests that the commodity group with the highest freight carbon footprint on all three of the road corridors considered is processed foods, followed by other mining, beverages, other chemicals, and wood and wood products. This is consistent with the findings of van Eeden and Havenga (Identification of key target markets for intermodal freight transport solutions in South Africa, 2010) who prioritised processed foods, beverages, chemicals (other), paper and paper products, and wood and wood products as being the most attractive markets for intermodal solutions, based on an assessment of quantities transported by road corridor (in tonne-km) and also a consideration of the ease with which these commodities can be palletised and/or containerised.

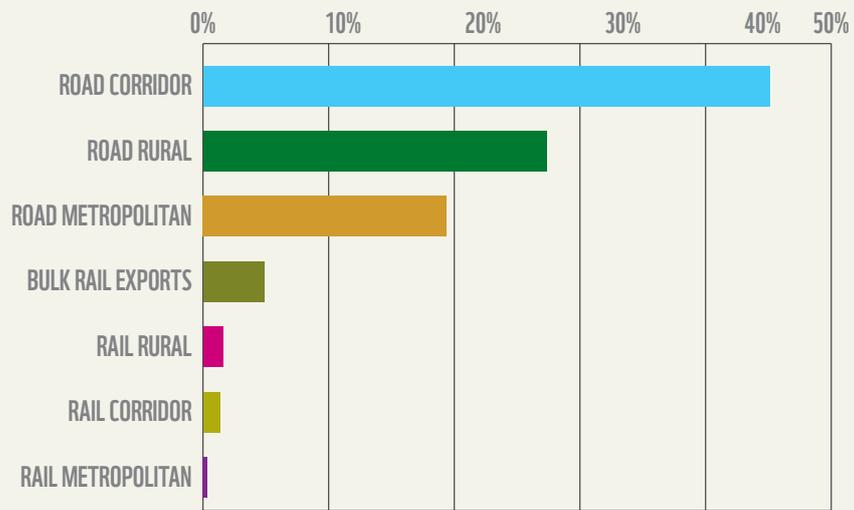
# PROCESSED FOODS

IS CONSIDERED THE COMMODITY GROUP WITH THE HIGHEST FREIGHT CARBON FOOTPRINT ON ALL THREE OF THE ROAD CORRIDORS

## The way forward

This analysis, although dependent on best estimates of freight flows and average emission factors, confirms that road freight gives rise to far greater GHG emissions in South Africa than rail freight. In particular, corridor-road freight makes the largest contribution to freight GHG emissions, followed by rural-road freight and metropolitan-road freight, as shown in the figure below.

**Figure 4 Summary of percentage contribution to freight GHG emissions by transport typology**



Examining the corridor-road freight on a commodity basis, it becomes apparent that the transport of processed foods makes up a particularly large proportion of this freight segment. The nature of this commodity grouping might offer intermodal transport solutions and contribute to reducing the emissions of freight transport in South Africa. From an emissions perspective, we therefore recommend that the focus of detailed freight transport modelling be on the processed-foods commodity group (for the corridor-transport typology).

Further work will investigate which mitigation opportunities and specific interventions are applicable to each transport typology, including corridor, rural and metropolitan road freight, as well as different commodity groupings, so as to contribute to a bottom-up indication of mitigation possible in the freight-transport sector.

## Addendum

### Summary of other freight activity data sources

This table lists some of these other key freight data sources.

Data source	Description and comment
StatsSA Land Freight Transport (discontinued)	<p>Up to and including 2003, the statistical releases on land freight transport provided a national overview of freight movements by commercial freight transport companies, showing:</p> <ul style="list-style-type: none"> <li>■ Number of vehicles in operation;</li> <li>■ Number of operating days;</li> <li>■ Idle vehicle days;</li> <li>■ Actual volume of goods transported (total, by month);</li> <li>■ Number of laden km travelled;</li> <li>■ Number of un-laden km travelled;</li> <li>■ Gross transport income and goods mass by commodity type.</li> </ul> <p>Some disaggregation was provided between Transnet and private transport enterprises, as well as month-to-month breakdowns, but the commodity breakdown was not provided for Transnet.</p>
StatsSA Land Transport Survey	<p>The StatsSA Land Transport Survey has been published quarterly since February 2009 and covers both freight and passenger transport. For freight transport, commodity breakdowns are only provided in terms of total transport income, which is not readily related to physical quantities, nor disaggregated into road and rail freight. Total transport tonnages and income are provided with a road and rail breakdown, but it is not possible to infer the commodity split from this data.</p>
Road Traffic Management Corporation	<p>The South African Road Traffic Management Corporation (RTMC) publishes data on the total number of registered vehicles and estimated kilometres travelled, disaggregated by vehicle type (including a truck class). Provincial breakdowns are given, although these are likely based on province of registration and are therefore of little use for national freight modelling.</p>
Provincial Freight Databanks	<p>Four functioning provincial freight databanks have been identified; they provide access to detailed information and statistics regarding transport at the provincial level. These cover KwaZulu-Natal, Limpopo, Mpumalanga and North West provinces. The data that these provide are often highly granular, presented at the level of individual provincial routes, rail links or traffic-counting stations. Typical data includes truck counts and classifications, as well as commodity breakdowns with tonnages inferred from vehicle types.</p> <p>These resources might be useful where local data is required for a specific purpose. They also provide infrastructural summaries that could prove helpful. However, in the absence of consistent data for all provinces, the usefulness of these databanks for national modelling purposes is likely to be limited.</p>
Transnet Annual Reports and Sustainability Reports	<p>Transnet provides certain aggregated freight statistics in their annual reporting, including:</p> <ul style="list-style-type: none"> <li>■ Total freight moved;</li> <li>■ Export coal;</li> <li>■ Export iron ore;</li> <li>■ General freight (Eskom coal, export manganese, container freight, domestic iron ore, cement, chrome, agriculture and automotive).</li> </ul> <p>As the only rail-freight provider in South Africa, these correspond to total rail-freight movements in the country. Although the locations of the iron ore and coal-export lines are known, the spatial distribution of other freight movements is not reported.</p>
South African National Roads Agency	<p>Traffic count data along major corridors</p>

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This is one in a series of publications produced by WWF South Africa's Low-Carbon Frameworks programme, which explores the shift to a low-carbon economy. We seek solutions for emitting fewer greenhouse gas emissions and enabling a flourishing South Africa, which delivers developmental outcomes and social equity.

The programme includes a focus on transport. WWF's transport project aims to provide a platform, expertise and interactive modelling to support labour, business and government in engaging with the challenges implicit in the low-carbon transition. Consideration will be given to the three tiers of interventions which will be required to effect the transition of this sector, being to REDUCE movement of goods and people, SHIFT to low-carbon modes of transport, from private to public, from road to rail, and IMPROVE mobility services, and energy and fuel efficiency.

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[www.panda.org](http://www.panda.org)

## The Green House

The Green House is a niche technical sustainability consulting firm based in Cape Town, with experience working on a wide range of energy, carbon and sustainability-related projects including strategic energy planning, carbon footprinting, and life cycle assessment. The Green House has significant experience in energy, transport, urban systems, bioenergy, biofuels, industry, commerce, agriculture, municipal waste management, mining and minerals.

[tgh.co.za](http://tgh.co.za)

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100% RECYCLED



47%

of freight is transported on metropolitan networks

1,762 KG CO<sub>2</sub>E PER TONNE-KM

results in short flights having the highest emissions of the transport modes



4 BILLION TONNE-KM

of processed foods were transported along the Durban-Gauteng road corridor in 2008

445 KT CO<sub>2</sub>E

Transnet's GHG emissions for fuel-related emissions in 2012

	<p><b>Why we are here</b> To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.</p> <p><a href="http://www.wwf.org.za">www.wwf.org.za</a></p>
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