Sustainability of Logistics:
Emissions impact of fresh fruit distribution

Dr Martin du Plessis, Prof Joubert van Eeden, Prof Leila Goedhals-Gerber
Agenda

• Why is carbon emissions important for SA Exporters
• Carbon emissions calculations
• Case Study: Fruit Exports – Packhouse to international port
• Decarbonising Logistics: Where to next?
• Stellenbosch University Initiatives
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Sustainable Development – Just a buzzword or a personal responsibility?

NASA, 2023
Sustainable Development – Just a *buzzword* or a *personal responsibility*?

“We are facing a man-made disaster on a global scale – irreversible damage to the natural world and the collapse of our societies”

Sir David Attenborough, 2019

“Climate change has evolved from being just another environmental problem to potentially the greatest threat facing our civilization”

Prof. Alan McKinnon, 2018

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

The Brundtland Report, 1987
Sustainable Development – Just a buzzword or a personal responsibility?

- growth
- jobs and prosperity
- fair pricing
- competitiveness

- economy
  - prosperity

- society
  - people
  - safety
  - health
  - disturbance
  - access
  - equity

- environment
  - planet
  - climate change
  - air quality
  - biodiversity
  - land use
  - waste

- planet

- people
Sustainable Development Goals (SDGs) AND Transport

Transport – Integrated into 8 SDGs

(United Nations, 2023)
The True Environmental Impact of Logistics

The externalities of freight logistics
- GHG emissions and climate change;
- Air and water pollution;
- Land usage;
- Asset disposal;
- Ecosystem damage and biodiversity loss;
- Accidents;
- Noise;
- Vibration;
- Visual intrusion;

Our focus
Fruit cold chain concepts

• The SA citrus industry is the second-largest citrus exporter in the world, after Spain.

• Citrus fruit contributes 60% to fruit export volumes and yields a revenue of approximately R20 billion per annum.

• The industry employs a cold chain to inhibit fruit deterioration and extend the shelf-life of fresh produce.

• A cold chain is a temperature-controlled supply chain allowing for national and transnational trade in perishable products such as fruit and vegetables.
Fruit cold chain concepts

• Cold storage helps to retain the freshness of perishable products for a lengthy period of time

• Helps to suppress bacterial and chemical reactions that occur under ambient storage conditions

• Ideal temperature during cold storage: respiration intensity of citrus fruit reduced by lowering the temperature to certain limits - reduces the rate of senescence
Fruit cold chain concepts

- Europe is the largest export market for South African citrus.
- South African citrus farmers export roughly 800,000 tons of citrus into the European Union (EU) annually.
- The EU recently changed to a steri-market for the fear of false codling moth (FCM) spreading into Europe.
- Fruit needs to be stored at sub-zero temperatures during the shipping and transportation processes.
- The cold-storage facilities in South Africa will need to implement new infrastructure to allow for this temperature control to take place.
  - Refrigeration accounts for approximately 30% of total export chain emissions.
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Navigating the World of Sustainable Freight

- Organisations
- Programmes
- Projects
- Tools
- Interventions

103 organisations and initiatives!
Navigating the World of Sustainable Freight

- Organisations
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Great guidance document for freight logistics!

Carbon emissions calculations

• Entity/facility emissions vs End-to-end/life-cycle-analysis SC emissions
  • Focus to date has been on entity/facility/region/country
  • Translating entity emissions into fair product end-to-end chain emissions

• Emissions calculation dilemma:
  • Accurate vs Simplicity
  • Comparable locally and internationally
Threat: Should Emissions Really Worry You?

• EU setting a global trend – The **Carbon Border Adjustment Mechanism (CBAM)**¹

• Energy- and GHG-intensive **goods** such as:
  • Cement, steel, aluminium, fertilizers, electricity and hydrogen (and what next???)
  • EU adamant: All importers to map entire product SC

• **Timeline** for CBAM?
  • Phased in by 1 October 2023, full implementation by 2026

• **Financial impact** of CBAM?
  • Africa might lose 5,7%² of its exports to the EU, equivalent to $16 billion in trade...

• Will your business be part of these statistics?

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A Carbon Mapping Framework for the International Distribution of Fresh Fruit

Martin Du Plessis¹, Prof Joubert van Eeden¹, Prof Leila Goedhals-Gerber²

¹ Department of Industrial Engineering, Stellenbosch University, South Africa.
² Department of Logistics, Stellenbosch University, South Africa.
The Problem

1. Carbon footprint (ABC kg CO₂e/kg fruit)
2. Total emission value (XYZ kg CO₂e) for the distribution chain
The Problem

Summary of the two problems which the framework solves:

1. There is no carbon mapping framework for fruit exports that can be used as an industry standard.

2. Insufficient emission intensity factors for distribution activities exist, which are needed in the calculation process.
The Framework:
A 20-page document that provides comprehensive, yet understandable guidance to industry and other stakeholders.
The scale of emissions: Results of typical example scenarios
The scale of emissions: Results of typical example scenarios

<table>
<thead>
<tr>
<th>Description of distribution activity</th>
<th>Carbon footprint (kg CO$_2$e/kg of fruit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport via road transport (Tzaneen-Cape Town)</td>
<td>0.1425</td>
</tr>
<tr>
<td>Offloading, Inland fruit facility, Loading (Cold store)</td>
<td>0.0570</td>
</tr>
<tr>
<td>Transport via road transport (Cold store to port)</td>
<td>0.0043</td>
</tr>
<tr>
<td>Offloading, Port of export, Loading (maritime port)</td>
<td>0.0111</td>
</tr>
<tr>
<td>Transport via deep-sea transport (Port of Cape Town to the Port of Rotterdam)</td>
<td>0.3991</td>
</tr>
<tr>
<td>Loss percentage of 3% during the distribution chain</td>
<td>0.0190</td>
</tr>
<tr>
<td>Total</td>
<td>0.6330</td>
</tr>
</tbody>
</table>
The 6 steps of the framework

We’ll go into the detail of each Step in the next slides...
Step 1: Identify all emission-generating activities
Step 2: Collect data of each activity

- Weight
- Distance
- Accounting for losses during distribution
- Required data per activity
Step 3: Select emission intensity factors

A COMPREHENSIVE SET OF EMISSION INTENSITY FACTORS IS SUGGESTED FOR ALL POSSIBLE EMISSION GENERATING ACTIVITIES
Step 3: Select emission intensity factors (four modes of transport)
Step 3: Select emission intensity factors (four modes of transport)

### Rail transportation

<table>
<thead>
<tr>
<th>Traction type</th>
<th>Load factor</th>
<th>Empty running</th>
<th>Emission intensity (g CO₂e/t-km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>80%</td>
<td>50%</td>
<td>31.5</td>
</tr>
</tbody>
</table>

### Air transportation

<table>
<thead>
<tr>
<th>Type of aircraft</th>
<th>Emission intensity (g CO₂e/t-km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combi</td>
<td>990</td>
</tr>
<tr>
<td>Freighter</td>
<td>560</td>
</tr>
<tr>
<td>Unknown</td>
<td>800</td>
</tr>
</tbody>
</table>

### Deep-sea ocean transport

<table>
<thead>
<tr>
<th>Vessel type and source</th>
<th>Trade lane or route</th>
<th>Refrigerated container in one direction (filled with fruit)</th>
<th>Refrigerated (filled with fruit) in one direction and empty return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container vessel</td>
<td>Africa to-from Asia</td>
<td>155.4</td>
<td>243.1</td>
</tr>
<tr>
<td></td>
<td>Africa to-from Europe</td>
<td>174</td>
<td>276.2</td>
</tr>
<tr>
<td></td>
<td>Africa to-from North America (East Coast/Gulf/West Coast)</td>
<td>193.5</td>
<td>327.7</td>
</tr>
<tr>
<td></td>
<td>Intra-Africa</td>
<td>233</td>
<td>368.2</td>
</tr>
<tr>
<td></td>
<td>Other (only used when origin-destination pair is not listed)</td>
<td>179.2</td>
<td>285.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conventional reefer vessel</th>
<th>Emission intensity factor (g CO₂e/t-km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Source: Author developed from LSP data)</td>
<td>All routes</td>
</tr>
<tr>
<td></td>
<td>48.6</td>
</tr>
</tbody>
</table>
Step 3: Select emission intensity factors
(Logistical facilities that handle and store fruit)

<table>
<thead>
<tr>
<th>Containers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handling (kg CO₂e/container)</td>
</tr>
<tr>
<td>Storage (kg CO₂e day⁻¹)</td>
</tr>
<tr>
<td>Source: author developed from LSP data and (Smart Freight Centre, 2019).</td>
</tr>
</tbody>
</table>

| Source: author established from literature. |

<table>
<thead>
<tr>
<th>Container in one direction</th>
<th>Container in both directions (forward and empty return)</th>
<th>Twenty-foot equivalent unit (TEU)</th>
<th>Forty-foot equivalent unit (FEU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inland container facility</td>
<td>11.5</td>
<td>87.0</td>
<td>175.0</td>
</tr>
<tr>
<td>Inland rail facility</td>
<td>18.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maritime container terminal</td>
<td>30.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The values in the table are approximate and subject to change based on specific logistical conditions and facility types.
Steps 4 and 5 – Calculating emissions and Carbon footprint of fruit

**Emission generating activity (1)**

- **Step 2:** Collect data
- **Step 3:** Select emission intensity factor
- **Step 4:** Calculate emissions of activity
  \[
  \text{Emissions} = \text{Collected data} \times \text{Emission Intensity Factor}
  \]
- **Step 5:** Calculate carbon footprint of activity
  \[
  \text{Carbon Footprint} = \frac{\text{Emissions}}{\text{Nett Weight of Fruit}}
  \]
Step 6: Determine overall carbon footprint and total emissions

\[
\text{Carbon Footprint}_{\text{Total}} = \frac{\sum_i (\text{Carbon Footprint}_i)}{(1 - \text{Losses})}
\]

\[
\text{Emission}_{\text{Total}} = \frac{\text{Carbon Footprint}_{\text{Total}} \times \text{Nett Weight of Fruit}_{\text{Destination}}}{1000}
\]

Unit:
- $\text{Carbon Footprint}_{\text{Total}}$: (kg CO$_2$e/kg fruit)
- $\text{Emission}_{\text{Total}}$: (t CO$_2$e)
Future plans – where to next and potential collaboration?
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Hierarchy of Intervention - how to go about decreasing freight emissions

1. Avoid
2. Shift
3. Improve
4. Invest

- Reduce the demand for freight movement
- Shift freight to lower-carbon modes
- Improve asset utilisation
- Improve energy efficiency
- New assets

Adapted McKinnon (2018)
Will being green cost you more?

<table>
<thead>
<tr>
<th>PHASE 1</th>
<th>PHASE 2</th>
<th>PHASE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>low hanging fruit</td>
<td>rebound</td>
<td>austerity</td>
</tr>
<tr>
<td>negative / zero mitigation costs</td>
<td>positive and rising mitigation costs</td>
<td>high mitigation costs</td>
</tr>
</tbody>
</table>

- minimal investment self-financing
- investment in low emission technologies
- rebalancing of logistical trade-offs
- internalisation of environmental costs
- sacrificing growth, return on investment and profitability

Emission reductions

Target
A Limitation or Opportunity?

- Environmental Impact
- Regulatory Compliance
- Competitive Advantage
- Cost Savings
- Reputation and Brand Image
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  • Collaboration with SRF centres in UK, India, China
  • Focus: Technology, Logistics operations and Policy
  • Research via funded projects and international partnerships
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- **Framework for fruit export emissions:**
  - Collaboration between Departments of Industrial Engineering and Logistics (EMS)
  - Developed process framework and SA specific emissions factors

- **Other WIP:**
  - **Third Party Rail Access:** Potential for energy and carbon savings known, implementation opportunities to be explored
  - **Smart Freight Centre:** Discussions for SSA truck emissions factors (GLEC focussed chapter)
  - WEF First Mover Coalition: Investigations into **Green Shipping Corridors**
  - Elements of a **Transport Ecosystem** for transition to Renewable Energy Freight Vehicles
Invite: Open for collaboration

• Contact us if you are keen to get involved:
  • Analyse your product distribution chain
  • Share activity data to improve emission factor reach or accuracy
  • Collaborate on future similar research projects
  • Study towards a Masters in Industrial Engineering/Logistics
Thank you
Enkosi
Dankie