Developing Feasible scenarios for bioenergy production in South Africa with Python

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science & innovation
Department: Science and Innovation
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation
SAEON South African Environmental Observation Network

BioEnergy in South Africa

- South Africa largely dependent on coal or imported crude oil to meet energy demands
  - Global drive to implement “greener” energy options with lowered carbon emissions
  - Obtaining finance for big infrastructure projects that emit carbon is increasingly difficult
- Solar and wind renewable energy sources can supplement electricity supply – reducing reliance on coal
  - Does not support industries that are reliant on petrochemicals or coal as an energy source

The bioenergy industry is seen as a potential way to address the above, while also providing jobs and stimulating a “green” economy

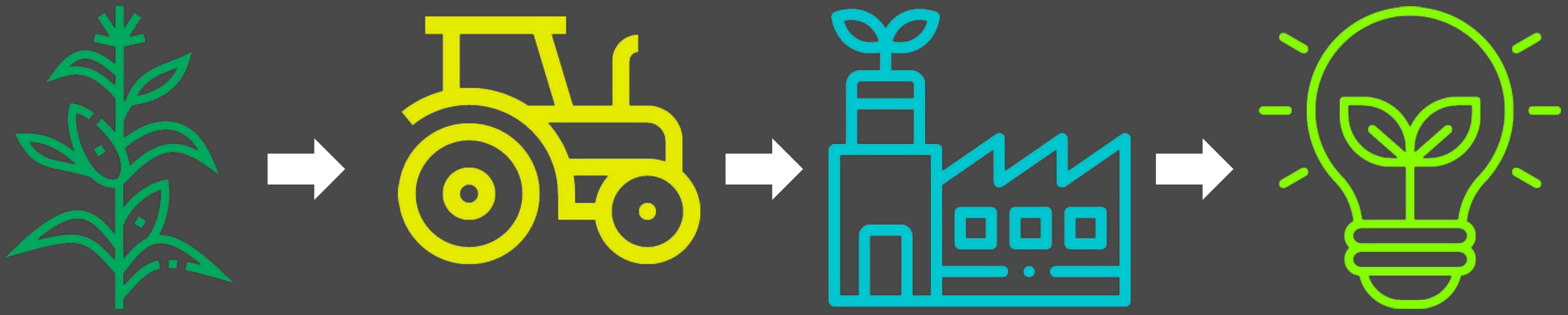
The BioEnergy Atlas of South Africa

- Funded by the Department of Science and Innovation
- Implemented by the Ulwazi Node of SAEON
- Data repository and searchable metadata catalogue:
    - Spatial information
    - Conversion Technology Database
    - Implementation Case Studies
    - Decision Support Tools
    - Industry Collaboration Toolkit

The BioEnergy Atlas for South Africa was conceived as an Open Source knowledge repository and decision support system to assist with the establishment of aa BioEnergy Industry in South Africa

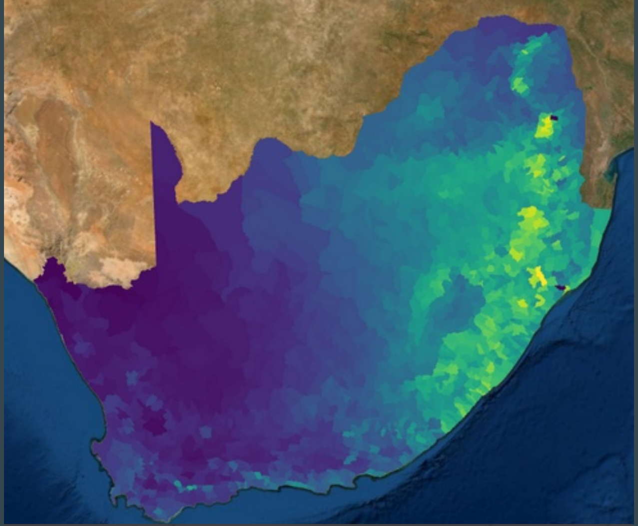
https://bea.saeon.ac.za/

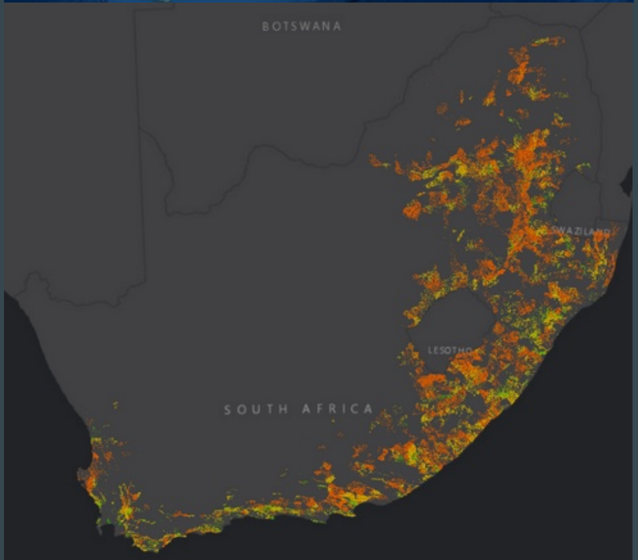
BioEnergy value chain -Simplified



Feedstocks

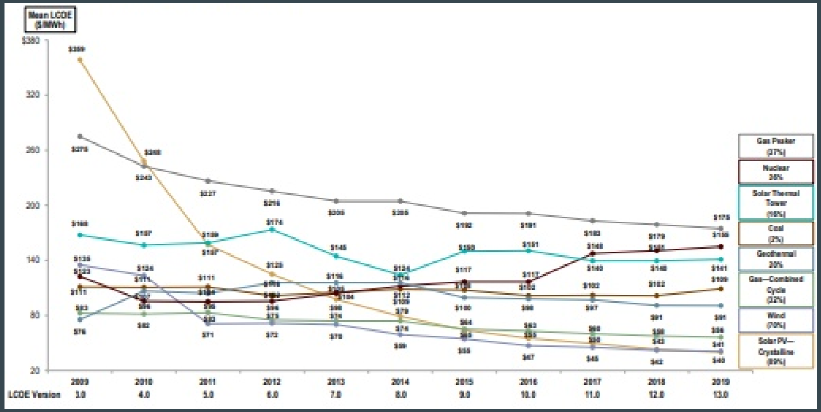
- The spatial availability of BioEnergy feedstocks follows a climatic gradient largely driven by rainfall.
- Majority of Biomass available for production is available in the eastern parts of South Africa
- **BioEnergy Feedstocks Include:**
    1. Energy Crops
    2. Agriculture and Forestry Residues
    3. Invasive Alien Plant Species
    4. Domestic Waste Streams
    5. Sewerage





Conversion Technology

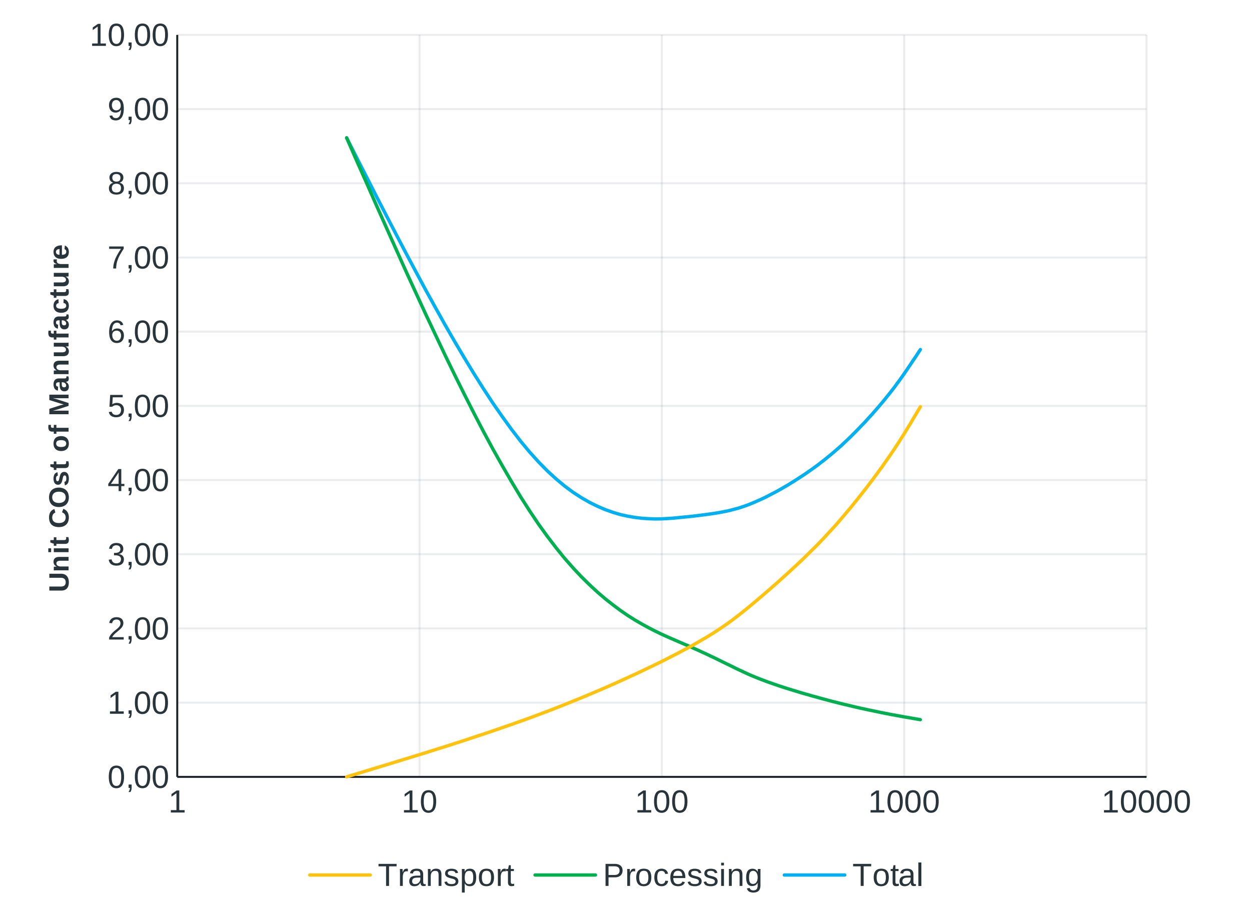
- Multiple Types of Conversion technology that use different processes to produce different types of BioEnergy.
- Subject to economies of scale.
- Large Capital Investments need to be tested for feasibility and compared as a levelised cost over such a planning period. ~ 20 years
- Technology + feedstock combinations that are price competitive to existing fuel sources are seen as feasible.



Assessment of feasibility should include evaluation against future demand and supply.

The Problem: How to develop scenarios for Feasible BioEnergy Production in South Africa?

Abstracted Problem



So where does the Python come in?

Modeling BioEnergy Feasibility required development a complex Spatial-logistical Model.

Components of the problem:

- Virtual Roads - for calculating the least cost off-road routes from feedstock source to nearest roadside depot.
- Location Allocation – for determining the locations of multiple bioenergy production facilities where road transport costs are minimized.
- Biomass acquisition – for calculating the road transport costs from Biomass source to a modelled production facility location.
- Biomass conversion model – uses production information in the form of linear models to calculate Capex, Opex, GHG emissions, generation potential and other parameters for each modeled facility location for each type of conversion technology.
- Comparisons Model – Uses the modelled outputs in order to perform nexus type comparisons in order to allow for selection of technology, feedstock, and Investment costs

repeat

So where does the Python come in?

Python is well suited for Scientific Programming Tasks.

Feature Rich Scientific Libraries such as:

- Scikit-learn
- NetworkX
- GDAL
- OGR

Simple Data analysis libraries with Standardized Syntax:

- Pandas
- Geopandas

Excellent Data Visualisation:

- Dash
- Plotly
- Matplotlib

Simple Data Integration with existing Databases:

- psycopg2

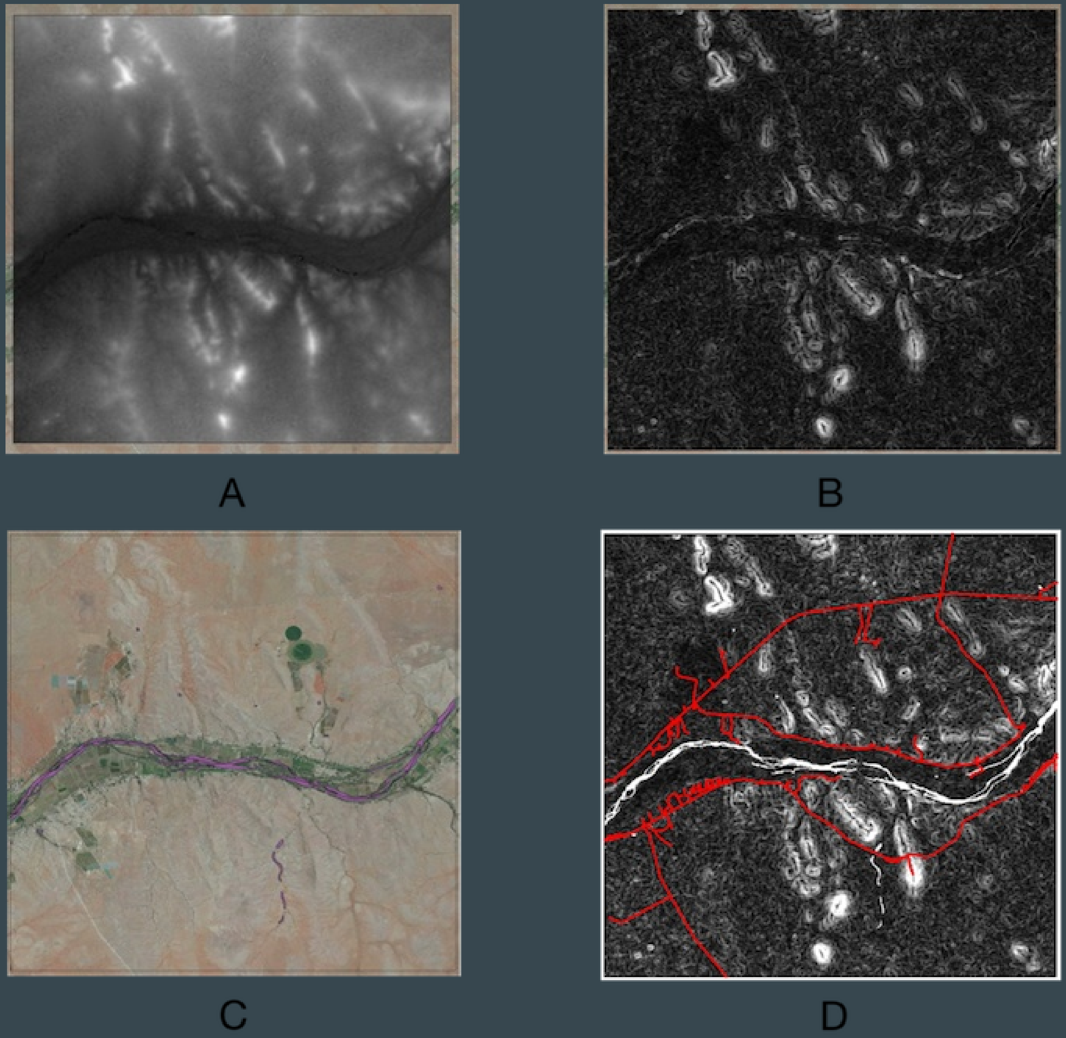
Virtual Roads Algorithm

Virtual Roads Algorithm

Example Area

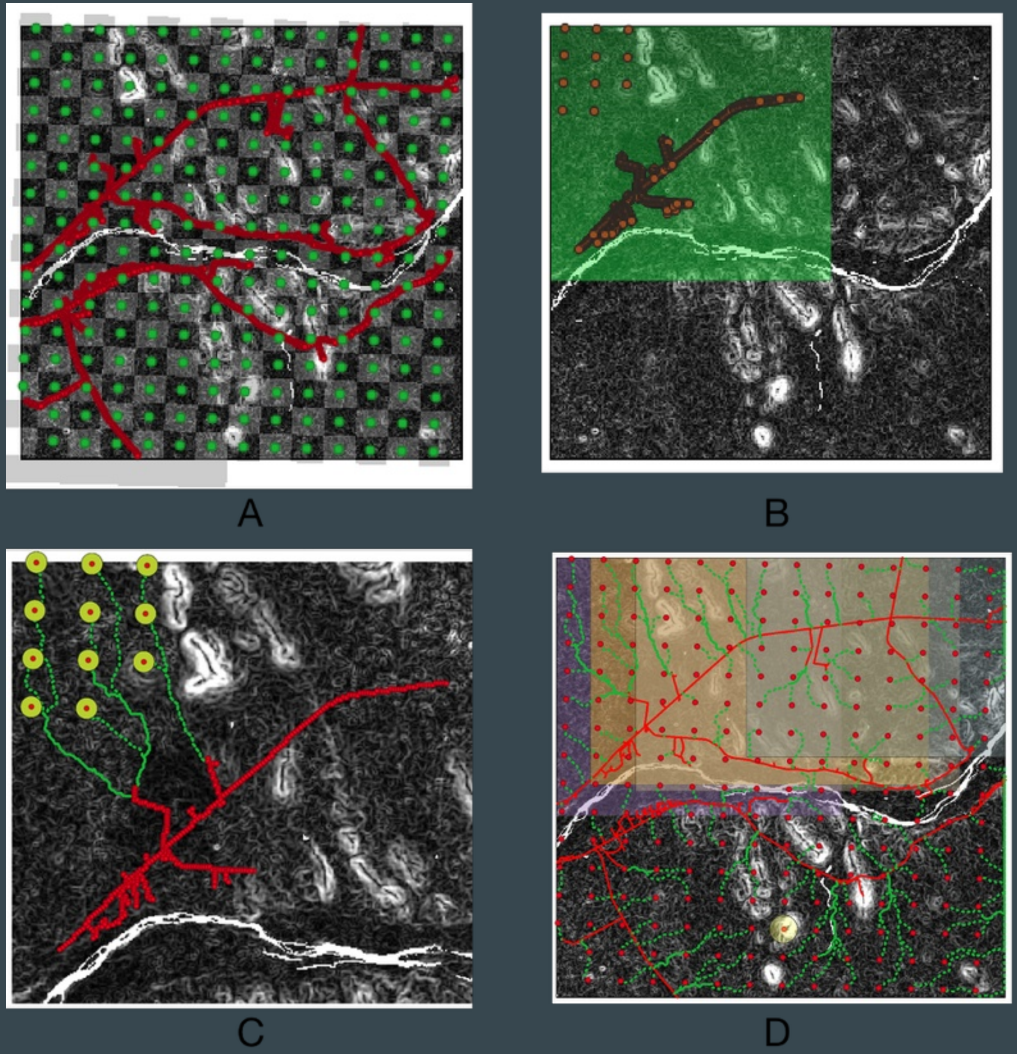
Logistics - Virtual Roads Algorithm

Generation of a cost surface

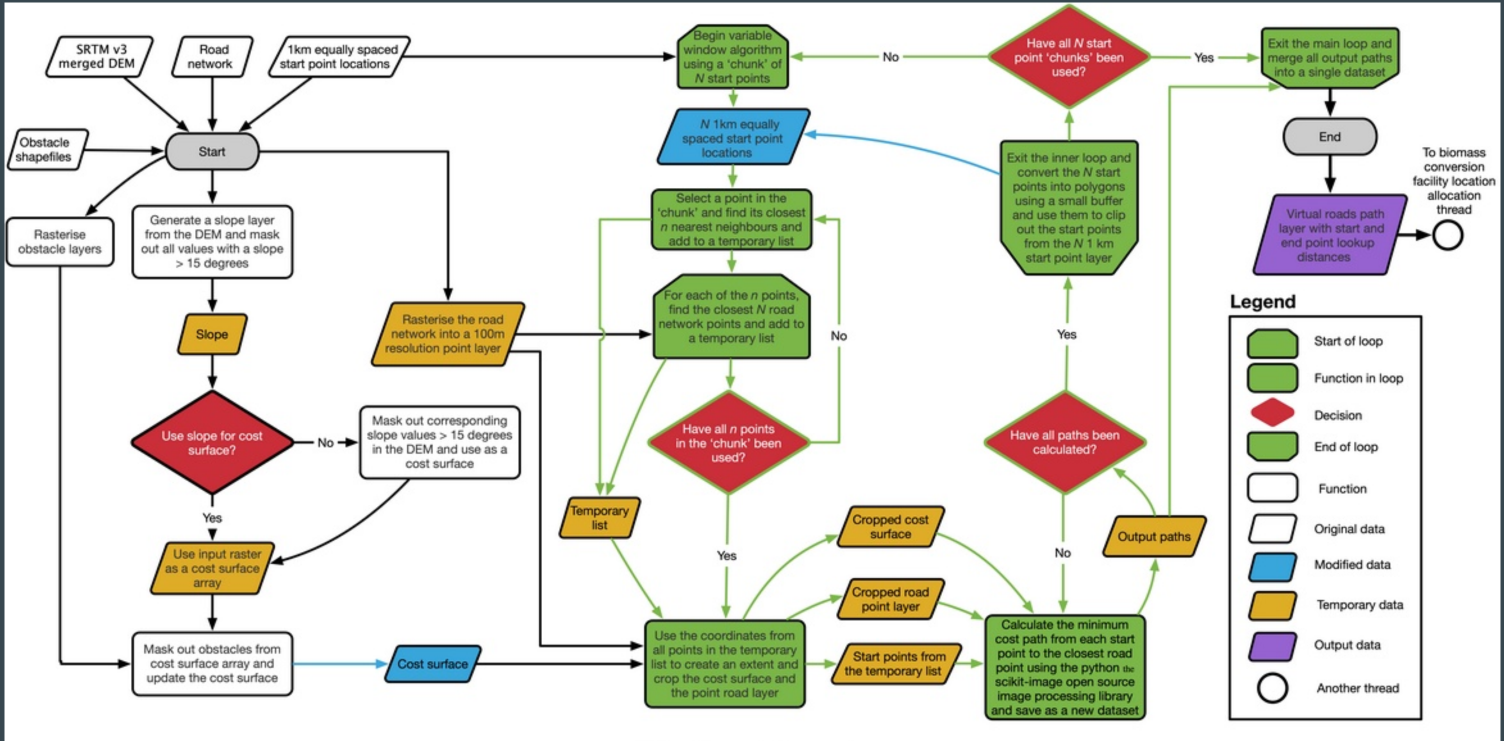


Logistics - Virtual Roads Algorithm

Windowed Approach



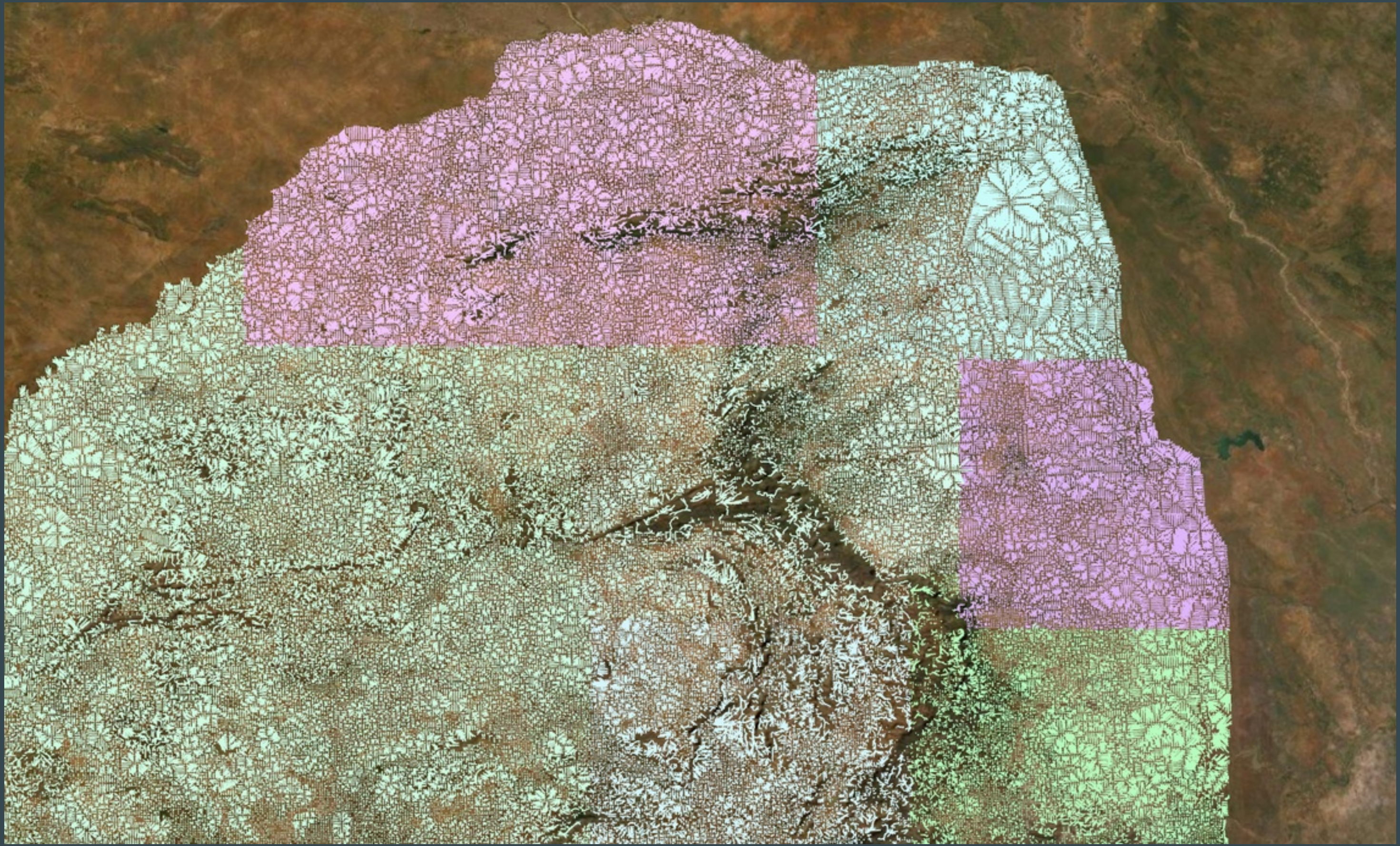
Logistics - Virtual Roads Algorithm



Virtual roads thread.
Authors: Marc Pienaar and Hayden Wilson

Logistics - Virtual Roads Algorithm

Result – Cost of transport to nearest Road



Logistics - Virtual Roads Algorithm

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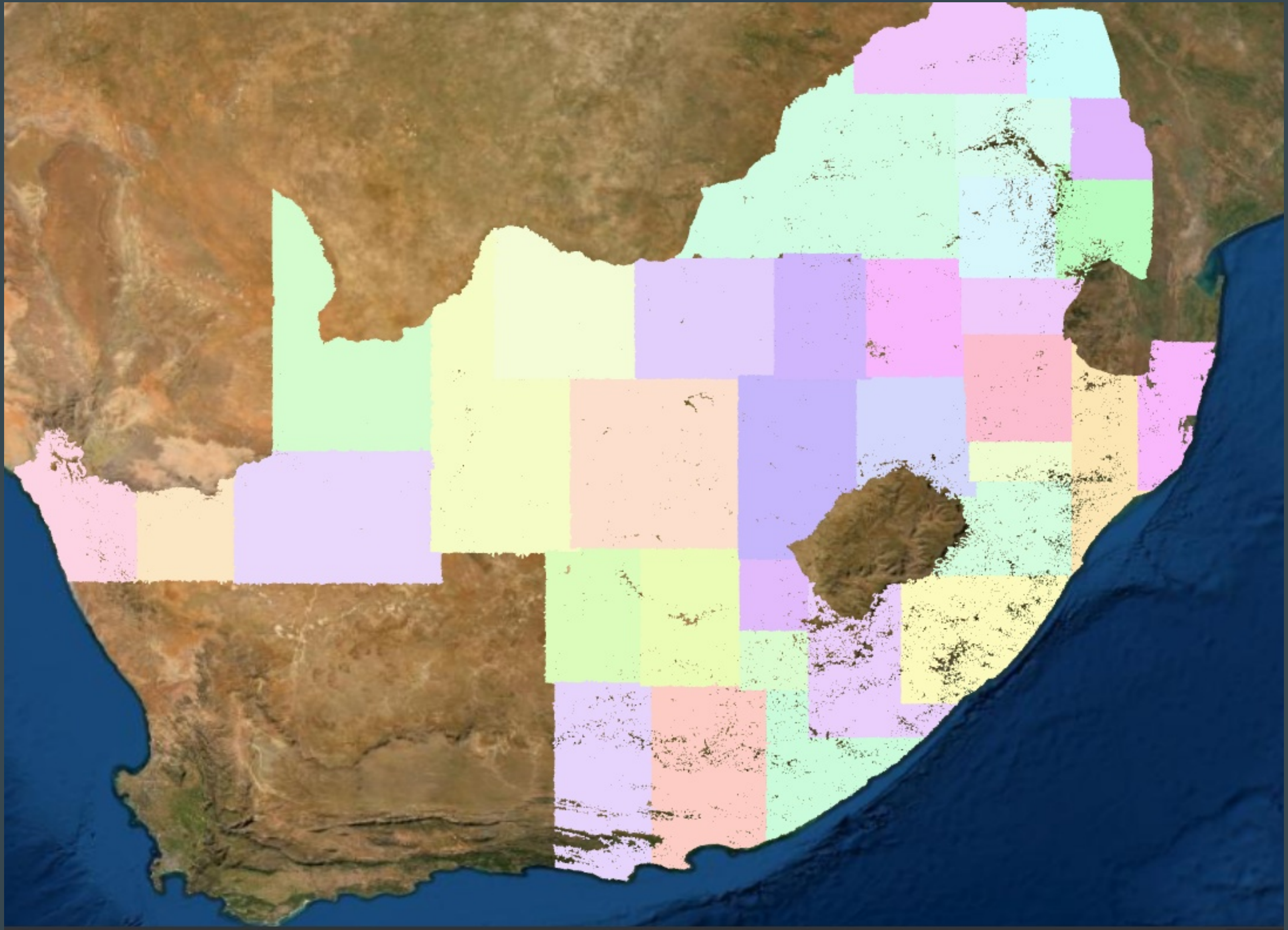
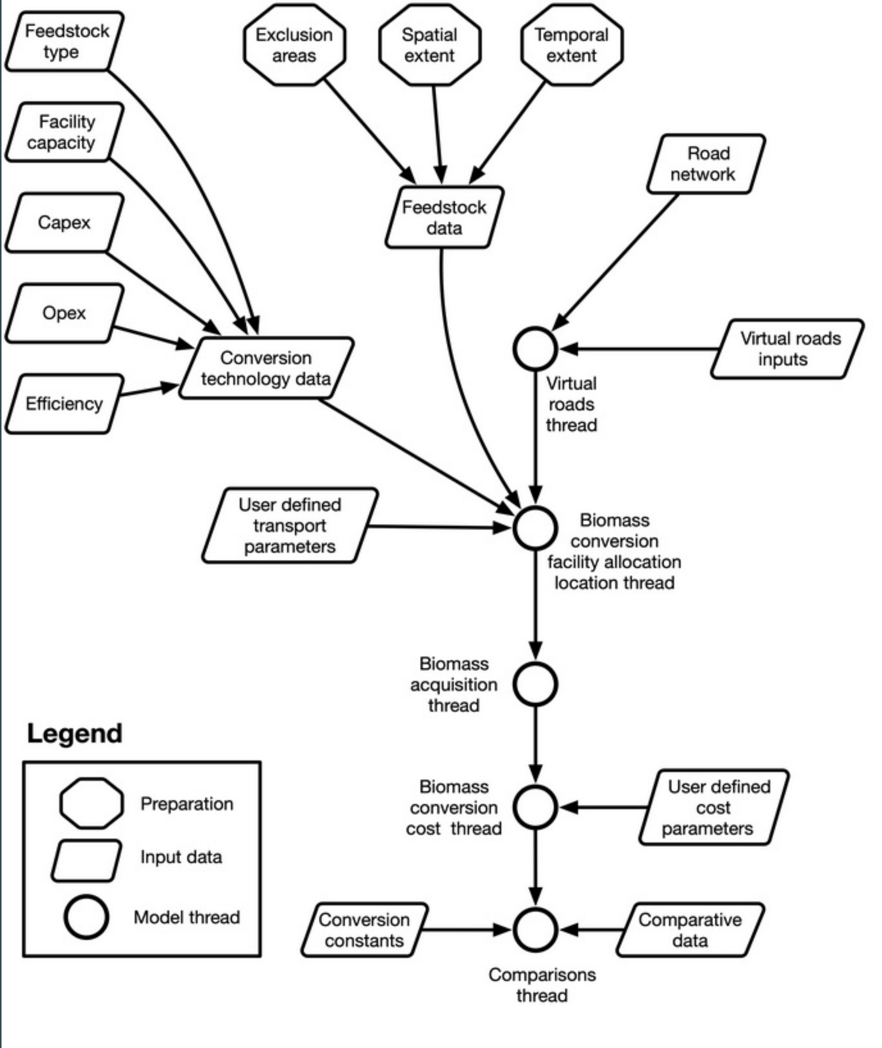


Locating BioEnergy Facilities



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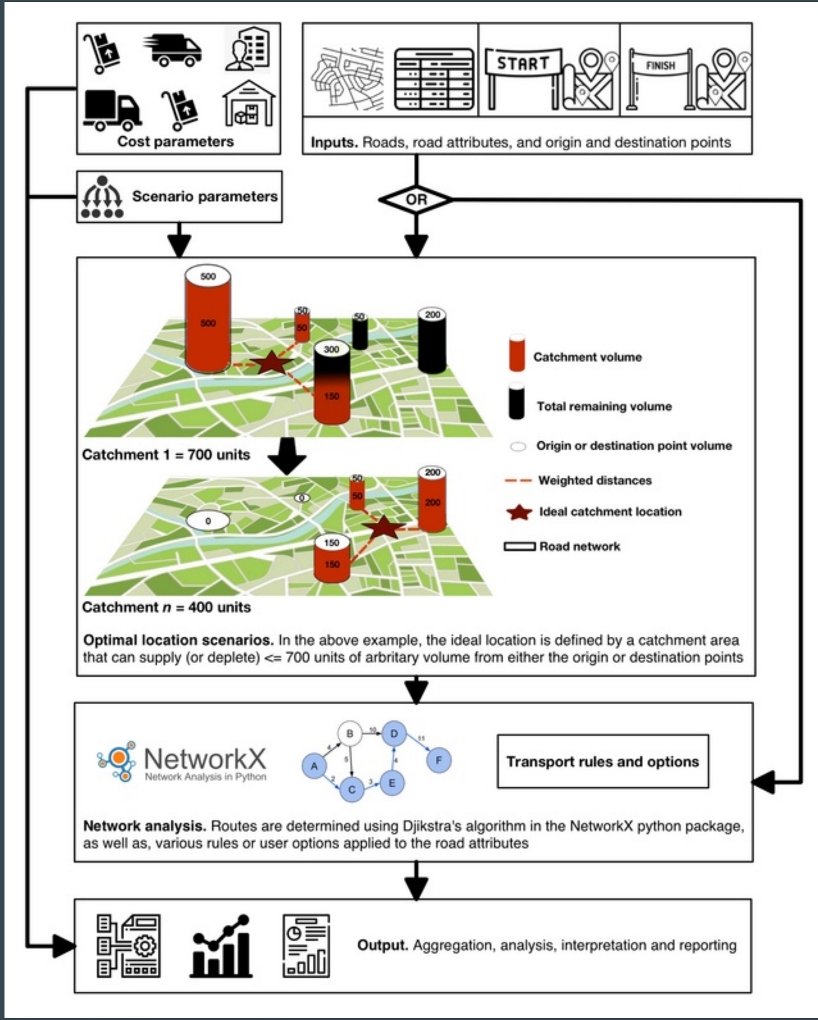

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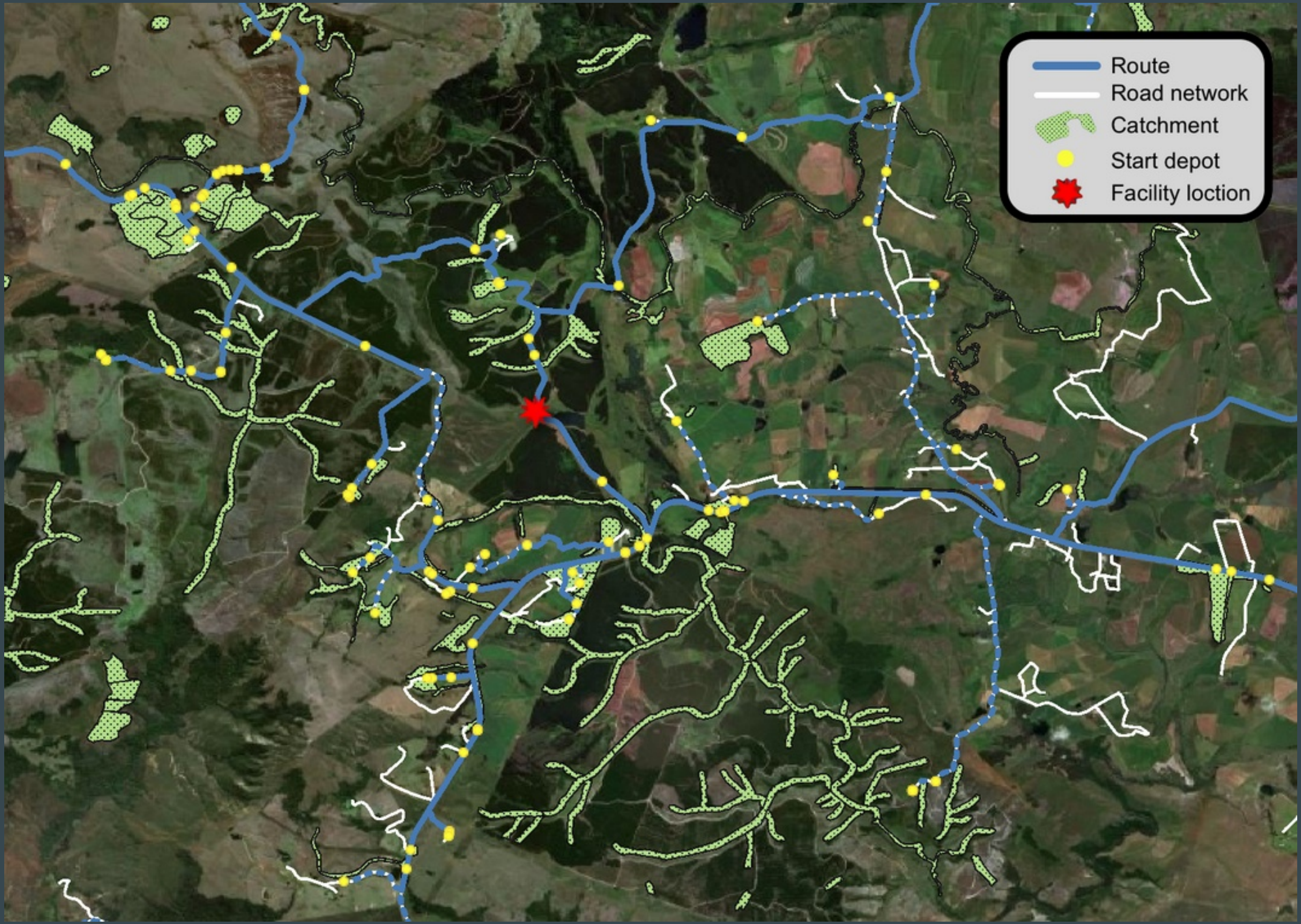
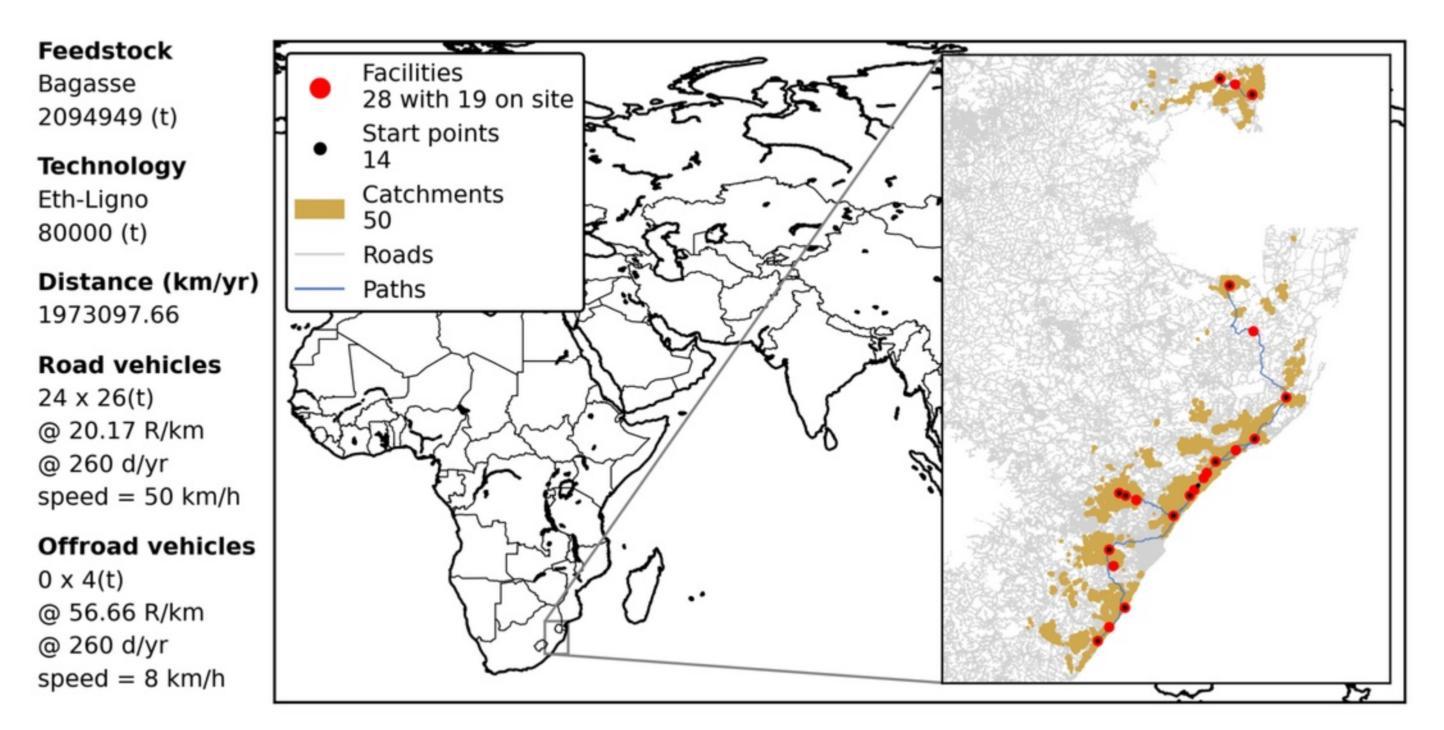


Model Outputs



Fancy Dashboard

Thanks!

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