Department of Chemical Engineering
Bioethanol optimisation group

Optimisation of biomass to bioethanol supply chain

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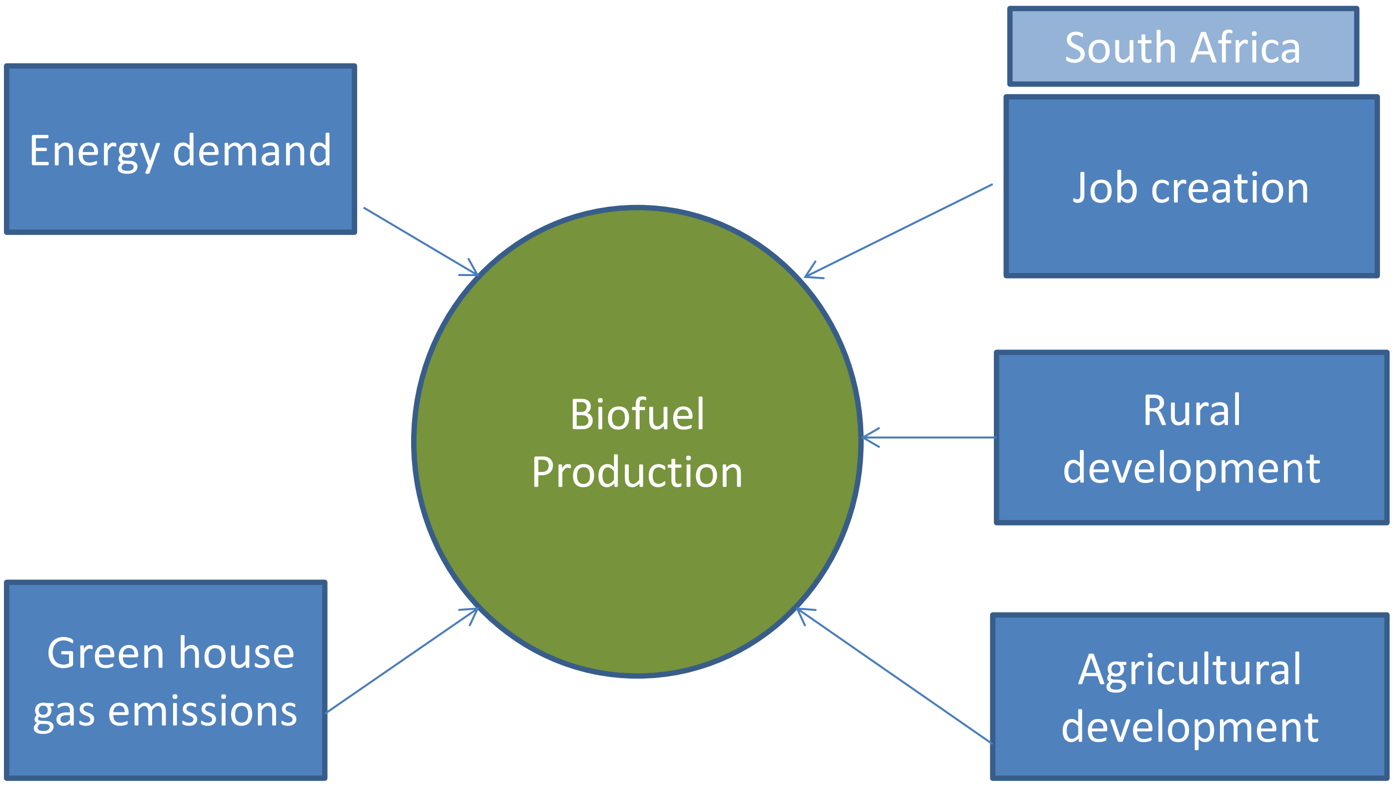
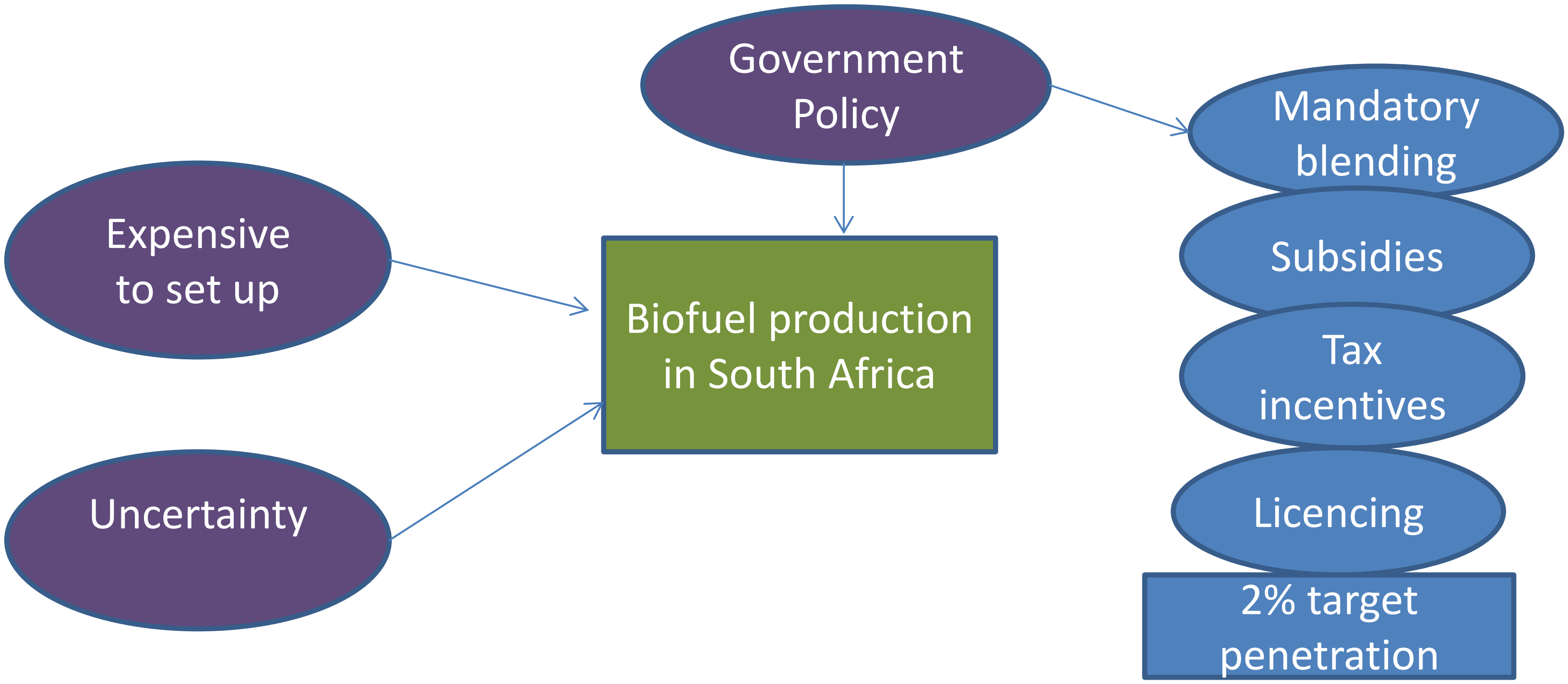
Background

- The driving force behind bioethanol production includes;



Background

- To date there is no large scale biofuel processing plant in South Africa.
- Commercialisation of bioethanol production has been a challenge due to the following;



Background

- Government Policy
  - Bioethanol production is heavily dependent on government policy.
  - Studies were done to compare high cost and low cost production.

Letete and von Blotnitz (2010)
Papastolou et al (2011)

Scope

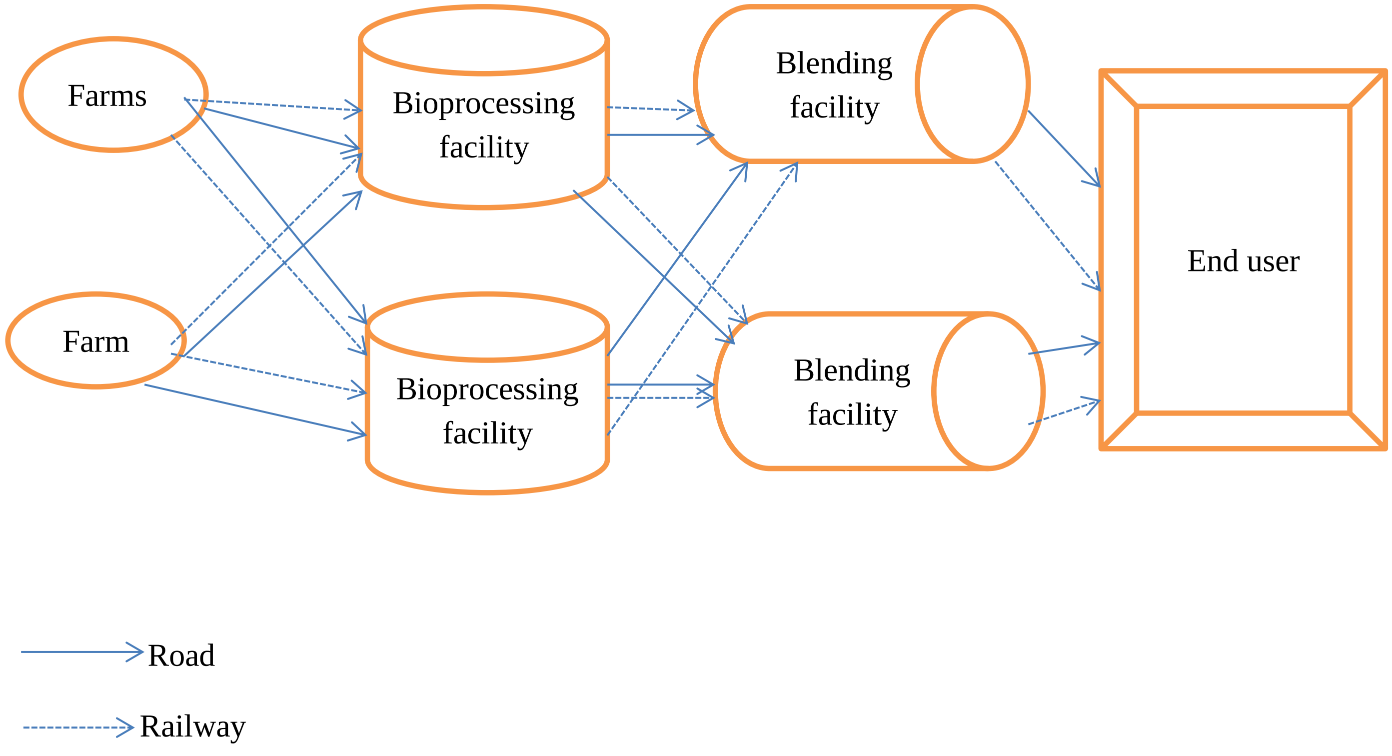
- To use mathematical programming to establish the optimal supply chain network for bioethanol production in South Africa by considering sugar cane and bagasse as biomass.

1. First generation	2. Hybrid first and second generation	3. Second generation (annexed sugar and bioethanol facility)

- The area to be considered is KwaZulu Natal, Mpumalanga and the Eastern Cape.

Bioethanol supply chain network

- Biomass to bioethanol supply chain network



Problem Statement

- Optimize size, location of production plant and amount of raw material to be used.

- Identify biomass source and determine cultivation rates that would optimize the supply chain.

- Optimize transportation distances and mode of transport for biomass and product.

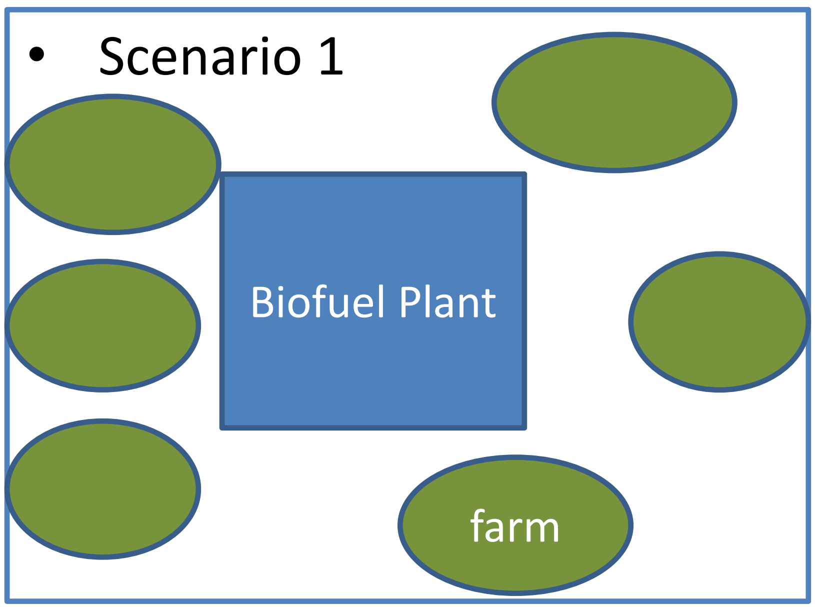
Why optimise?

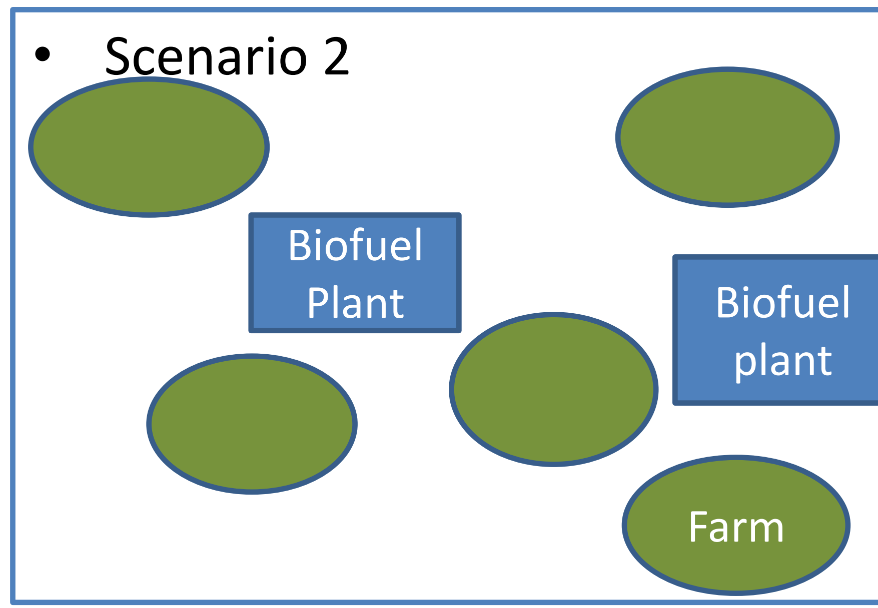
- To minimize the total cost of the whole biomass to bioethanol supply chain.

- To minimise the environmental impact of the bioethanol supply chain.

Location and sizing of processing facility

- High product demand
- Low biomass availability
- Rural Development





Eskiogul et al (2009)
Lin et al(2014)
Amigun and von Blottnitz (2005)

Transportation

- Studies show that transcportation costs of both biomass and bioethanol form a significant part of the overall cost.

- In South Africa, cane transportation constitute about 20-25% of the overall supply chain cost.

- Green house gas emissions from fossil fuels used in transportation constitute about 13.1% of the total GHG emissions which is about 39.5 Mt CO_2e with carbon dioxide constituting 97.8%, methane 1.7% and nitrous oxide 0.7%.
- Location of processing facilities in areas close to farms with high biomass cultivation rate would reduce the transportation costs.

Morrow et al (2006)

Yu et al (2009)

Giles et al (2007, DEA, (2009)

Production Technologies

- First generation technologies are economically favourable compared to other technologies. However, there is the food vs fuel conflict.

- Second generation technologies are more environmentally favourable but expensive to set up.

- Studies have been done to optimise the biomass to bioethanol supply chain and some concluded that hybrid first and second generation technology is economically and environmentally favourable.

Akgul et al (2012), Gariola et al (2011) Letete (2009), Malan 2007 , Botha et al (2006)

Research Approach

- Mathematical programming will be used to develop supply chain models for three scenarios:
  - First generation
  - Hybrid first and second generation
  - Annexed sugar and ethanol production (using bagasse)

- Data Collection-(use of Geographical Information Systems)
  - A map of the areas under consideration is to be generated and relevant layers are to be added (farms, transport network, production facilities and blending facilities). The area is then divided into regions. This will be used to determine size of cultivation sites and distance between facility locations.

Research Approach

- Model development- superstructure resulting from the supply chain network to be set as a Mixed integer linear programming model and solved using GAMS.
  - Variables:- Distance between farms and processing facilities
    -Distance between processing facilities and blending facilities
  - Continuous variable:-Plant size
  - Binary variables:- transportation mode, processing technology
    -Location of processing facility

- Analysis of results- Pareto curves as objectives are conflicting

Acknowledgements

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