A decision support system for carbon- and cost-effective transportation using multi-method optimisation

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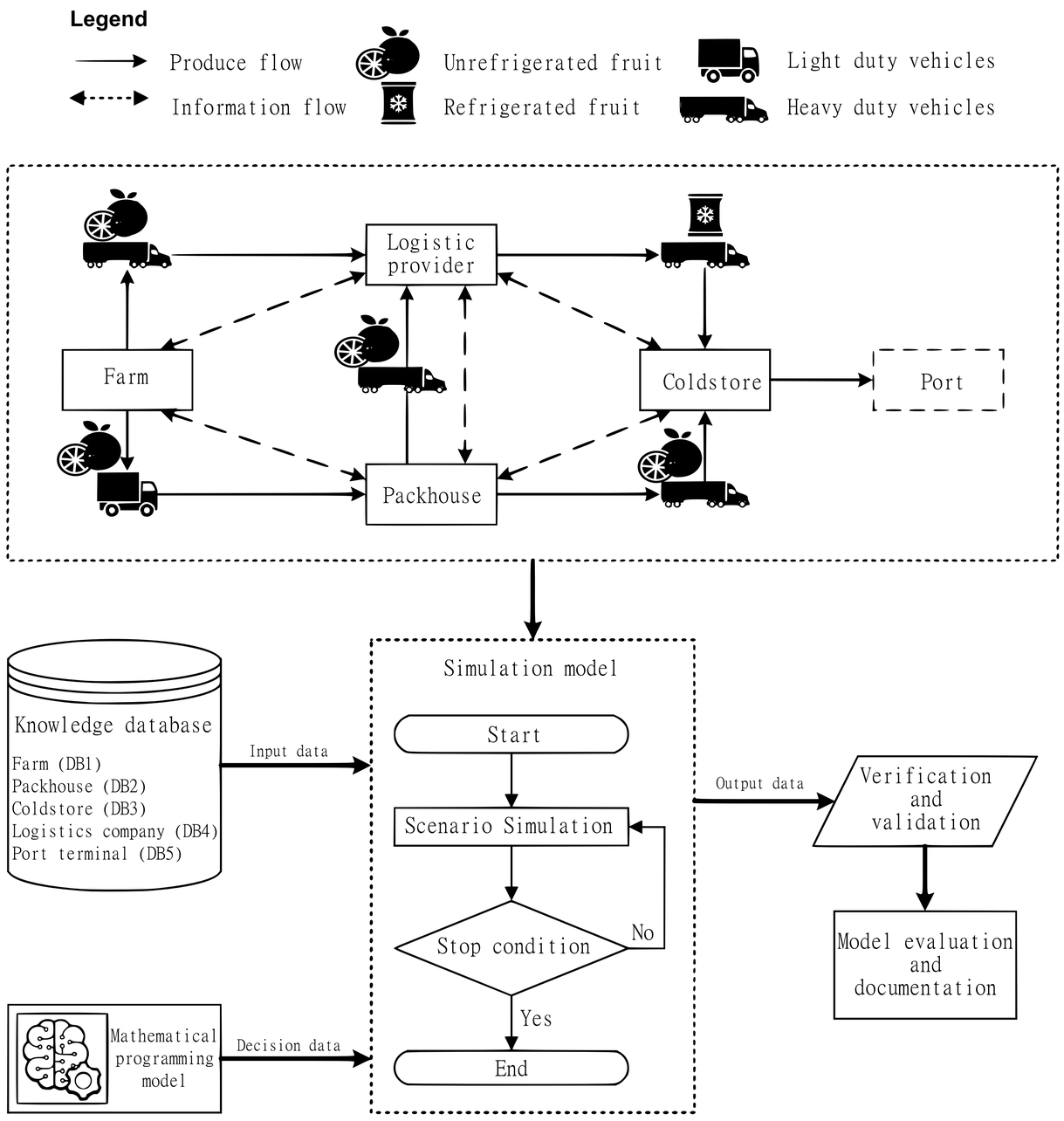
1. Introduction

Climate change has become one of the, if not the most, pre-eminent environmental issues threatening the human population and natural ecosystems. The levels of carbon emitted, mainly due to burning fossil fuels, have drastically increased due to the successive industrial revolutions that connect different people, economies, cultures and technology — increasing the dependence on the adequate movement of goods by increasingly complex and longer global supply chains. The carbon emissions of global supply chains, and in particular their distribution component, account for a majority of companies' overall greenhouse gas emissions and carbon footprint. The carbon emissions from transportation logistics vary among supply chains and are a function of the fuel consumption of the vehicles used for transportation and distribution. Influential factors and trends contributing to fuel consumption — *e.g.* transport mode, vehicle attributes, driver behaviour, environmental factors, and operations — must be taken into account when attempting to minimise the environmental impact of transportation activities. There is, however, a trade-off in respect of minimising cost.

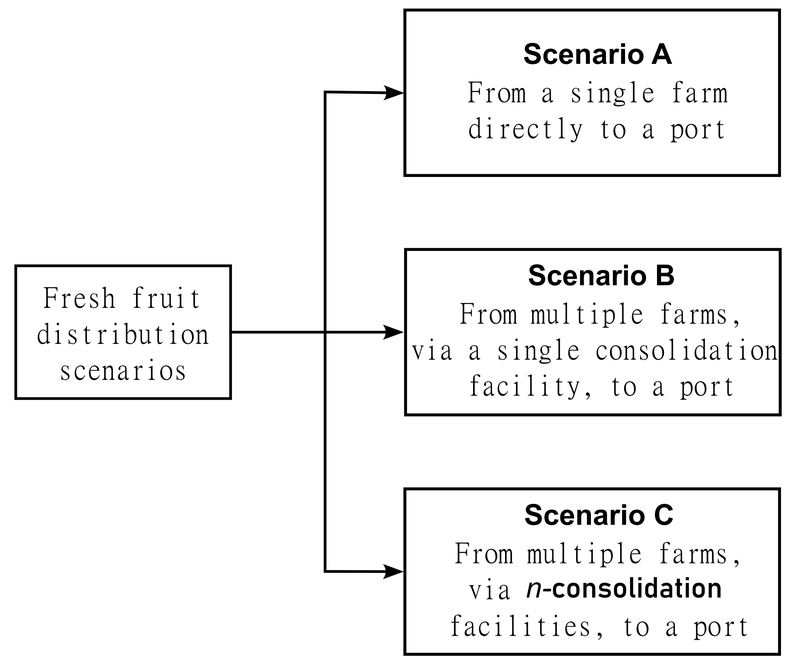
2. Decision support framework

The proposed framework aims to investigate the utility of applying agent-based modelling and mathematical-based programming to model real-world transportation conditions and decisions related to the farm-to-port distribution leg of the South African fruit export supply chain. An agent-based modelling approach is necessary so as to model the complexities associated with the various driver behaviours and operational decisions. Different bi-objective mixed integer programming models are to be formulated so as to improve various aspects pertaining to the aforementioned, *e.g.* facility location and fleet scheduling. A *decision support system* (DSS) is to be designed, developed, and implemented to facilitate the decision-making process in order to aid stakeholders towards minimising both cost and carbon emissions. The framework is graphically illustrated in the figure below in the form of a high-level schematic data-flow diagram.



3. Base-case distribution scenarios

The base-case distribution chain comprises of three possible scenarios:



Distribution chain diagrams aims to: Form the input basis of all emissions estimation projects for the shipment of fresh fruit, and prescribe for which activities emissions must be calculated.

4. Research aim formalised

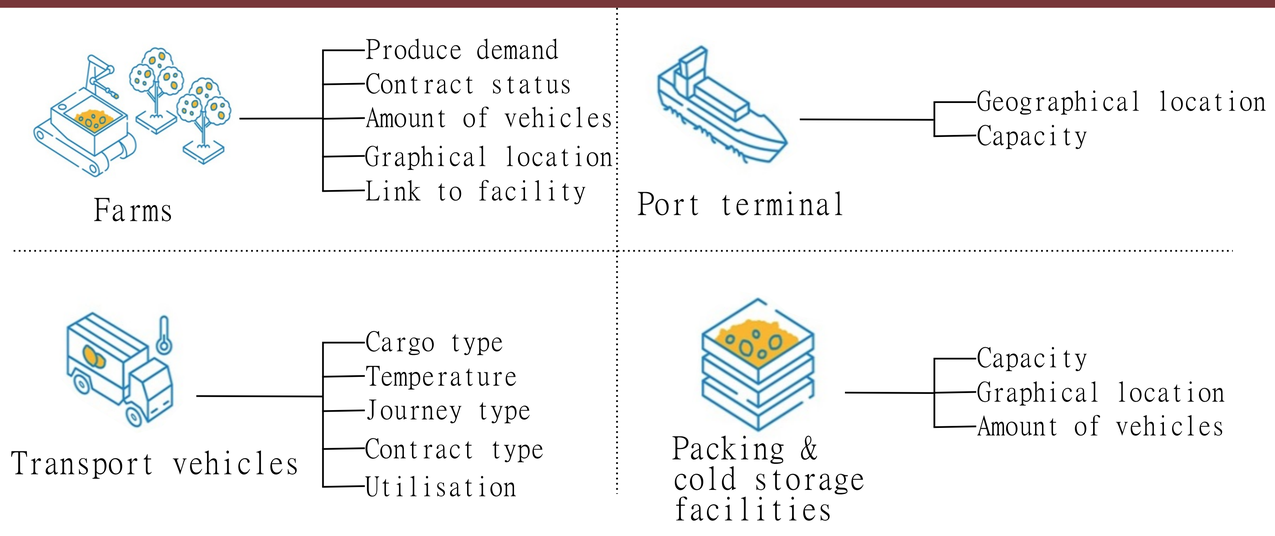
The input data comprises of:

1. The information related to origin-to-port the distribution activities
2. market dynamics and demands for interacting agents,
3. describing the fleets of available delivery vehicles,
4. behaviour and decision making of road freight drivers, and
5. time-windows of which distribution relies on.

The performance of all possible scenarios is to be evaluated and compared by considering the number of required consolidation hubs, trucks, total travel time, total travel distance, and different behavioural policies among drivers. With the aim of:

1. Evaluation of the heterogeneous impact of climate change on various agents
2. Better understanding of interactions and behaviour of transportation agents
3. Capability to restructure supply chain to handle increasing demand and traffic
4. Improved location allocation and vehicle routing
5. Improved fuel efficiency, cost effectiveness, and driver performance

5. Agent Database



6. References

[1] du Plessis MJ, van Eeden J & Goedhals Gerber L, 2022, *Distribution chain diagrams for fresh fruit supply*, Journal of Transport and Supply Chain Management, **16(0)**.

[2] Searle C & van Vuuren JH, 2021, *Modelling forced migration: A framework for conflict-induced forced migration modelling according to an agent-based approach*, Computers, Environment and Urban Systems, **85**, pp. 101568.