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Capacity constraints and inefficiencies through the live export supply chain process

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Executive summary

The Australian livestock industry is a complex set of supply chains between farms, feedlots, processing export depots, ports and export markets. About 20 million head of cattle and 50 million head of sheep are moved between these enterprises each year, with significant differences in supply chain paths by month and by year. The project was able to characterise the nature of the live export supply chains and the current constraints, bottlenecks and inefficiencies. Stakeholder consultation and TraNSIT modelling were used to quantify the bottlenecks in the supply chain. While there is a long list of issues, many of the identified constraints are due to commercial considerations and regulatory issues. Infrastructure constraints were identified on a number of road and port access areas where investments would improve the movement of livestock from property to export depot and then on to the export port. We calculated that the industry spent nearly $52 million and $14 million on cattle and sheep movements respectively from properties to port between 2016 and 2017, whereas transport for all cattle and sheep movements in Australia costs $572 million and $211 million respectively. All Australian agricultural industries spend around $5.3 billion per year (2015) moving products from property to their final market destination.

Supply chains are long and fragmented and the sourcing of animals is geographically spread. Changes to ownership and a lack of vertical integration also leads to inefficiencies within supply chains, captured in this study by the observation that inefficiencies and bottlenecks are often ‘caused somewhere else by someone else’. A number of landside infrastructure investments were identified that could have a significant impact such as improving northern beef roads, improving the road between Mount Gambier and Portland and moving the export facilities from the Inner Harbour at Fremantle Port to the Outer Harbour in Cockburn Sound. However, the small scale of the live export industry means it is unlikely that infrastructure investments would be made solely on the basis of cost savings to the industry.

Ensuring the most efficient pathways to ports are maintained should be a focus for the industry, with the greatest savings to be gained by having guaranteed access to high performance vehicles to the closest port. The northern wet season (December–January–February) limits cattle supply from properties. However, the changing date of Ramadan over the next 10 years is an opportunity for northern cattle exporters as the date moves back each year and by 2025 will begin to coincide with the northern wet season. There is spare capacity (about 40,000 head per month) for the wet season and the development of infrastructure that ‘stores’ cattle to ensure supply for the Indonesian market should be considered. The likely development of the onshore (unconventional) gas industry in the Northern Territory could result in the building of roads that provide year-round access. If that is the case, the industry could work with companies that are developing gas fields to have roads constructed for mutual benefits.

We recommend future research to understand port costs and to develop a better understanding of receiving market infrastructure constraints. The initial assessment in this study showed that significant savings in time and transport costs can be made in Indonesia by making simple adjustments to discharge and truck loading processes at port. Similar opportunities are likely in other receiving markets.

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1 Background

1.1 Introduction

The Australian livestock industry is a complex set of supply chains between farms, feedlots, processing export depots, ports and export markets. About 20 million head of cattle and 50 million head of sheep are moved between these enterprises each year (2015 data), with significant differences in supply chain paths by month and by year. Live export represents a significant proportion of these supply chains (particularly in the Northern Territory, Western Australia and Queensland) with nearly one million beef and over two million sheep exported annually. A substantial portion of these live export supply chains are in regions with sparse road networks coupled with long distance transport, seasonal access issues, and limited port and shipping capacities. Disruptions to existing supply chains or market changes substantially reduce the ability for the industry to adapt under these challenges. Infrastructure investment and changes to regulation can substantially reduce the impacts of these bottlenecks, and an evidence-based approach can inform government and industry which investments provide the best value. Any reduction in travel times will also result in animal welfare benefits.

To provide a holistic view of the costs and benefits of infrastructure investments and regulatory changes in agriculture supply chains on transport logistics, the Australian Government (with state government co-investment) funded the development of the Transport Network Strategic Investment Tool (TraNSIT). TraNSIT optimises transport routes for tens of thousands of enterprises and hundreds of thousands of vehicle trips between the enterprises and their markets, providing input into operational and investment decisions. The Australian Government originally commissioned the development of TraNSIT in 2013 to address the cattle transport challenges in northern Australia (Higgins et al., 2013), before it was extended to broader Australian agricultural commodities (Higgins et al., 2017). A key feature of TraNSIT is that its development included input from over 110 industry organisations and government agencies across Australia. Industry organisations included processors, feedlotter associations, farming associations, exporters, traders, transport providers and transporter associations. This broad input ensured expertise and access to high-quality data on a very large scale, not previously achieved for agricultural transport in Australia. As a result, TraNSIT can be applied to a large range of applications, such as live export supply chains. It now represents every supply chain movement through every beef and sheep and goat enterprise across Australia, including animals supplied into the live export supply chain. It represents monthly movements from farm to export depot to port and can be used to analyse congestion features at each port.

1.2 Project aim

Improving supply chain efficiencies was identified as a high priority in LiveCorp’s 2016–2020 Strategic Plan, which stated:

‘Providing technical advice where appropriate and available to improve facilities, skills development and infrastructure that increases the efficiency of, and access to, primary and secondary ports and removes bottlenecks in supply chains.’

This project aimed to review and identify opportunities to improve efficiencies and reduce capacity constraints and bottlenecks, and to prioritise those that most limit industry sustainability and growth.

2 Project objectives

This project undertook to provide the Australian livestock industry and related stakeholders (e.g. federal and state governments) with a capacity to inform infrastructure (and related supply chain) investments and make strategic and tactical investments that reduce the economic impact of bottlenecks and capacity constraints from supply chain disruptions and altered markets. Working and consulting closely with stakeholders (through roundtable discussion and bilateral meetings) across the livestock supply chain, this was achieved by:

1) Obtaining an initial stocktake of the current supply chains from key representatives, which identified bottlenecks, capacity constraints and operational inefficiencies to existing livestock supply chains through export depots and ports in Australia. Following this were targeted bilateral meetings and discussion and an audit of facilities.
2) Identifying capacity constraints of existing export supply infrastructure in Australia for future live export trends and new markets.
3) Identifying bottlenecks in key destination ports (Asia and Middle East) that impact markets and supply chains of Australian livestock export.
4) Identifying a range of infrastructure investment and other scenarios that are likely to reduce the costs from existing bottlenecks and allow the industry to adapt to future markets, changes in existing markets and/or changes to regulations.
5) Applying TraNSIT and other methods to provide a quantitative baseline analysis of current livestock (beef and sheep) export supply chains in light of current bottlenecks, showing the logistics costs across the industry and identifying hot spots.
6) Applying TraNSIT to evaluate the likely cost savings and broader economic benefits of the scenarios identified by stakeholders aimed at reducing or eliminating the bottlenecks.
7) Communicating the key findings and priority investment scenarios to key government agencies (state and federal), working groups, industry stakeholders and industry associations.

3 Methodology

The project employed a combination of scientific approaches and methodologies to meet the objectives as outlined below.

3.1 Initial consultation

The first step in the project involved discussions with key supply chain participants and representatives from producer and exporter groups. Discussions were held with representatives from key government agencies involved in industry promotion and regulation in most states where exports occur and the Australian Government Department of Agriculture and Water Resources. Discussions were also held with the livestock Exporters Associations: Northern Territory Livestock Exporters' Association, Queensland Livestock Exporters' Association, Western Australian Livestock Exporters' Association, and the South East Australia Livestock Exporters' Association. In those meetings the project objective and research questions were introduced and a discussion on the current state of the live export industry and possible capacity constraints were discussed.

3.2 Baseline analysis

In order to better understand capacity constraints a baseline analysis of the most recently available sheep and cattle movements involved in the live export industry was undertaken. The baseline analysis was derived from National Livestock Identification System (NLIS) data by mapping the path of about 32,000 vehicle movements (semitrailer equivalents) to export depots and ports, representing 1.18 million cattle and 1.8 million sheep transported per year. NLIS data for livestock movements for the sheep and cattle live export supply chains (2014–2016) was via a data access agreement with the NLIS (Integrity Systems Company). NLIS data were used in TraNSIT to create a synthetic set of freight movements across the road network, and model costs for every vehicle trip. These vehicle trip routes were then aggregated to provide a freight movement density map. The analysis, mapping and costing data were derived from the TraNSIT model (Higgins et al., 2015; described in Appendix 9.1).

For the baseline analysis the costs of sea transport, port handling and shipping were also derived. Using data published by each port authority or company, a draft port handling costing model was produced for each port that exports cattle or sheep. The draft port handling costing model used for the project remains untested and unverified, however, as it will require input from other industries, shipping companies and port operators (which was beyond the scope of this project). The port handing model includes the following cost components: livestock loading, ship berthing, port dues, animal feed and demurrage. The model was applied to each cattle and sheep shipment from January 2015 to June 2017, to estimate a total port cost and cost per head.

Published port of origin to port of destination data for sheep and cattle (2014–2017) was also compiled to derive the receiving market supply channels. These data were taken from the mandatory reporting to the Australian Parliament on livestock mortalities for exports by sea, as required by Marine Orders Part 43 under subsection 425(1AA) of the *Navigation Act 1912* (taken from http://www.agriculture.gov.au/export/controlled-goods/live-animals/live-animal-export-statistics/reports-to-parliament, accessed November 2017).

3.3 Scenario development

Improvement scenarios were developed through detailed consultation and roundtable discussions held with key representatives from both producer and exporter groups in Brisbane, Perth, Darwin and Adelaide. The baseline analysis* was presented in these consultations and discussions, to set the context of the live export industry relative to all agricultural freight and transport and to identify critical infrastructure bottlenecks and capacity constraints. A presentation of the baseline analysis and a categorisation of issues was used to guide the discussion. The categories of issues were physical infrastructure constraints, operational constraints on adequate infrastructure, regulatory

* 2014–2016 sheep and cattle movements from property to registered premises and onward to the port and the indicative ground up costs per movement

inefficiencies and duplication (and new regulations), port infrastructure and operational constraints, and input cost and operational inefficiencies.

3.4 Scenario testing and analysis of costs

To provide a holistic view of the costs and benefits of infrastructure investments and regulatory changes in agriculture supply chains on transport logistics in Australia, CSIRO developed TraNSIT. TraNSIT uses ground up cost models and a routing algorithm that optimises transport routes for tens of thousands of enterprises and hundreds of thousands of vehicle trips between the enterprises and their markets. The outputs provide input to inform operational, investment and regulatory decisions from small scale to freight and supply chain strategies at a national scale. TraNSIT provides a rigorous, quantitative understanding of what infrastructure investment and regulatory scenarios may mean to supply chain flows and transport costs across all agricultural enterprises. This input will be critical to optimising value from available investment options.

TraNSIT was initially built to model livestock supply chains in northern Australia in 2012–2013 through an initiative by the Office of Northern Australia and with co-funding from the Northern Territory, Western Australia and Queensland governments. In 2014, TraNSIT was extended to all beef transport in Australia through a Meat and Livestock Australia initiative (Higgins et al., 2015). In 2014–2015, the tool was further used to inform various road upgrades and regulatory changes for the beef industry, including sealing of roads in north Queensland and changing of tick clearing regulations for transport of cattle direct to abattoirs. These applications all incorporated significant industry (e.g. cattlemen and feedlot associations, Livestock and Rural Transporters Association) and government (transport and agriculture departments) support in the form of data and expertise to calibrate and refine the model. Rigorous validation with the beef industry also occurred, to ensure outputs stood up to extensive scrutiny and were supported by stakeholders.

4 Results

4.1 Outcomes of the initial consultation

Several stakeholder meetings were held with the live export industry (through the Livestock Export Association) and government representatives. In those discussions constraints and operational inefficiencies were identified and grouped as represented in Table 1, with the detailed outcomes of the meeting captured in Appendix **Error! Reference source not found.**. The initial consultation also h ighlighted the challenges of a fragmented and long supply chain that inevitably creates inefficiencies. The long transport distances and geographic spread make the live export supply chain prone to extreme and unpredictable climatic events that can cause significant and major disruptions. Multiple transactions and changes of ownership along the supply chain add actors and also leads to inefficiencies, with many industry actors expressing frustration with the previous or next step in their supply chain. Another challenge raised was the ability of the industry to lobby for infrastructure upgrades given the size of the industry relative to other agricultural industries; any request would be considered against priorities in other agricultural sectors and more broadly against all freight. A common observation was that inefficiencies and bottlenecks are often '*caused somewhere else by someone else*', in other words rectifying inefficiencies and bottlenecks remain out of the control and/or influence of individual businesses. While new market opportunities were discussed there was no concern expressed that new market development would cause issues. The exception was that protocols for China would require additional capacity in registered premises to allow for isolation of consignments of animals, although stakeholders considered that if that became a problem it would quickly resolve through a commercial solution.

The discussions also highlighted similar recent reviews. In Western Australia the Northern Beef Infrastructure Audit (ACIL Allen Consulting, 2016) conducted an audit of infrastructure supporting the beef industry in the Pilbara and Kimberley regions to determine constraints and opportunities and identify projects that would encourage and support the expansion of the northern Western Australian beef industry. The report listed priorities in road upgrades, port loading facilities and wash and truck facilities relating to the supply of cattle to live export. The report also set out likely transport savings of each different development and included the options of value adding through the development of an abattoir, which has subsequently been built and has begun operations.

The Northern Beef Roads project (CSIRO, 2016) evaluated 60 proposed infrastructure changes that could bid for funding through the $100 million Australia Beef Roads Program. The infrastructure proposals included road sealing, bridge upgrades to allow higher productivity vehicles, and upgrades to intersections and access to processing facilities. The infrastructure upgrade options were provided by state and territory governments and through direct industry engagement via roundtable discussions. Each upgrade scenario was then assessed, allowing comparison of cost savings and the impacts of cattle and beef transport flows. In the stakeholder consultation these options were still considered relevant and as such were re-analysed in this project.

Table 1 Grouping of capacity constraints and operational inefficiencies from initial consultation.

Categories	Examples provided
Physical infrastructure constraints	Road access during wet season in northern Australia. Requests for new ports and development of new registered premises in some locations. First and last miles issues across the road network.
Operational constraints on adequate infrastructure	Capacity of registered premises. Road maintenance and upgrades through the remote network. First and last mile issues at key infrastructure points of supply chain. Lack of supporting facilities, breakdown pads and wash facilities. Curfews on local roads.
Regulatory inefficiencies and duplication (and new regulations)	Biosecurity regulations. Changes to bovine Johne's disease management. Implementation of individual identifiers on sheep in Victoria. Australian Maritime Safety Authority inspections.
Port infrastructure and operational constraints	Port scheduling issues, especially in northern ports. Operational delays causing additional demurrage charges. Lack of preference to live export vessels in port scheduling and access. Ship loading constraints in remote ports.
Input cost and operational inefficiencies	Potential competition for cattle with new abattoir developments. Cost of and access to fodder in remote ports.

4.2 Baseline results

4.2.1 Cattle movements to ports

Table 2 provides a summary of cattle transported to each port using NLIS data. There is no strong seasonality for major cattle export ports, except for a small drop in January/February for Darwin.

Table 2 Number of cattle transported to each port by month (2014–2016 average).

Port	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Darwin	16,496	24,067	46,678	40,916	36,991	52,564	45,044	34,836	36,827	34,103	42,915	44,851
Brisbane	356	353	566	576	424	509	453	632	896	795	375	589
Townsville	26,616	26,240	25,168	38,331	26,855	13,424	17,902	15,270	20,018	19,896	17,105	12,761
Kurumba	418	658	956	633	1,564	2,626	670	2,526	1,299	2,260	1,904	1,273
Portland	2,573	4,033	4,466	6,473	6,485	3,496	9,191	9,738	7,576	2,761	5,889	13,661
Broome	2,646	0	2,359	19,431	17,030	17,936	14,045	9,450	7,887	11,186	2,634	0
Wyndham	0	0	2,816	4,694	9,905	5,411	2,031	1,904	0	1,690	2,905	0
Geraldton	3,192	4,238	487	0	889	0	0	0	755	1,460	4,783	2,366
Fremantle	26,087	21,644	5,243	11,660	4,198	10,177	5,599	5,038	11,171	11,996	13,349	16,730
Adelaide	7,525	4,244	0	24,876	0	10,034	3,374	2,135	0	0	0	2,387
Geelong	2,033	0	0	1,931	1,490	0	1,340	1,772	2,204	0	1,500	2,812

Table 3 shows the transport costs for each port, as modelled using TraNSIT. Differences in costs between ports are due to transport distance, road train access to the port, and road conditions (sealed versus unsealed). The number of animals transported to export depots is often different to the number of animals transported from export depots to ports because:

- some export depots are multi-purpose and not all animals that arrive proceed to the port
- some export depots in the south supply more than one port
- some animals are transported directly from export-accredited farms to the port.

Table 3 Transport costs to export depots and ports for cattle.

			Property to export depot			Export depot to port		
Port	**Number of head to port**	**Number of head to export depot**	**Average distance (km)**	**Cost ($ million)**	**Cost per head**	**Average distance (km)**	**Cost ($ million)**	**Cost per head**
Darwin	456,287	576,960	727	$21.464	$37.20	111	$3.312	$7.28
Brisbane	**6,523**	**6,480**	**591**	**$0.236**	**$36.41**	**169**	**$0.08**	**$12.34**
Townsville	259,586	263,280	373	$5.758	$21.87	77	$1.452	$5.59
Kurumba	**16,788**	**16,320**	**420**	**$0.398**	**$24.38**	**0**	**0**	**0**
Portland	76,340	113,520	363	$2.659	$23.42	57	$0.382	$5.01
Broome	**104,606**	**177,840**	**557**	**$5.131**	**$28.85**	**74**	**$0.600**	**$5.74**
Wyndham	31,355	27,360	541	$0.817	$29.86	18	$0.122	$3.88
Geraldton	**18,171**	**30,480**	**527**	**$0.943**	**$30.93**	**15**	**$0.060**	**$3.29**
Fremantle	142,892	157,440	568	$5.268	$33.46	134	$1.347	$9.42
Adelaide	**54,574**	**24,720**	**448**	**$0.668**	**$27.02**	**52**	**$0.255**	**$4.67**
Geelong	15,082	23,760	345	$0.527	$22.18	179	$0.137	$9.08
TOTAL	**1,182,206**			**$43.884**			**$7.785**	

Fig. 1 shows the annual number of vehicles (semitrailer equivalents) along each road segment, as modelled using TraNSIT. It includes transport from farm to export depot and export depot to port. The map highlights the significance of the roads around collection points for the industry.

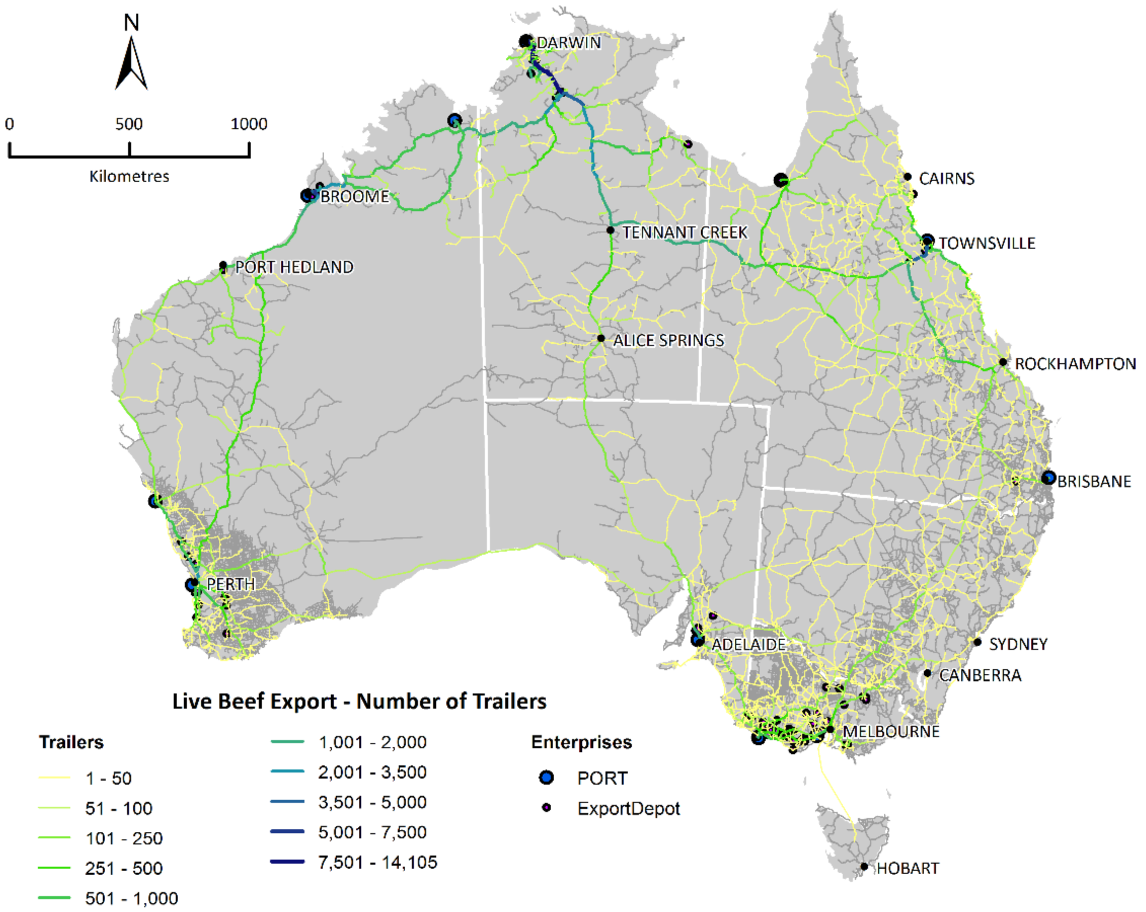

Fig. 1 Average number of vehicles per year for cattle only. Includes trips from farm to export depot and export depot to port.

4.2.2 Sheep movements to ports

Table 4 shows the average monthly movements of sheep to the main export ports. For Port Adelaide, only 2016 data was used due to difficulty in determining destination ports for some export depots in the NLIS data.

Table 4 Number of sheep transported to the port by month (2014–2016 average). Port Adelaide is based on 2016 information only.

Port	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fremantle	67,713	119,377	151,066	119,713	162,238	104,097	164,544	140,026	122,269	197,101	123,553	158,794
Adelaide	51,451	0	0	39,445	21,734	2,991	0	32,917	0	0	0	0
Portland	0	23,850	104	30	338	302	155	390	50	217	252	55

Table 5 shows the transport costs for each port, as modelling in TraNSIT. Similar to cattle, the differences relate to the journey, whether there is port access for higher performance trucks or whether they need to 'breakdown' loads, road conditions and regulatory barriers to movement. In the case of Fremantle and Adelaide, congestion on urban roads was mentioned as an issue by stakeholders, but there is no data available to validate those concerns and to factor that into the costings.

Table 5 Transport costs to export depots and ports for sheep. 2016 data used for Adelaide.

			Property to export depot			Export depot to port		
Port	Number of head to port	Number of head to export depot	Average distance (km)	Cost ($ million)	Cost per head	Average distance (km)	Cost ($ million)	Cost per head
Portland	25,743	16,800	629	$0.204	$12.11	29	$0.026	$1.02
Adelaide	148,538	189,600	487	$1.694	$8.93	79	$0.289	$1.96
Fremantle	1,630,455	1,582,800	275	$8.274	$5.22	89	$3.178	$1.95
TOTAL	1,804,736							

The number of animals transported to export depots is often different to the number of animals transported from export depots to ports because:

- some export depots are multi-purpose and not all animals that arrive proceed to the port
- some export depots in the south supply more than one port
- some animals are transported directly from export-accredited farms to the port.

Fig. 2 shows the annual number of vehicles (semitrailer equivalents) along each road segment, as modelled using TraNSIT. It includes transport from farm to export depot and export depot to port.

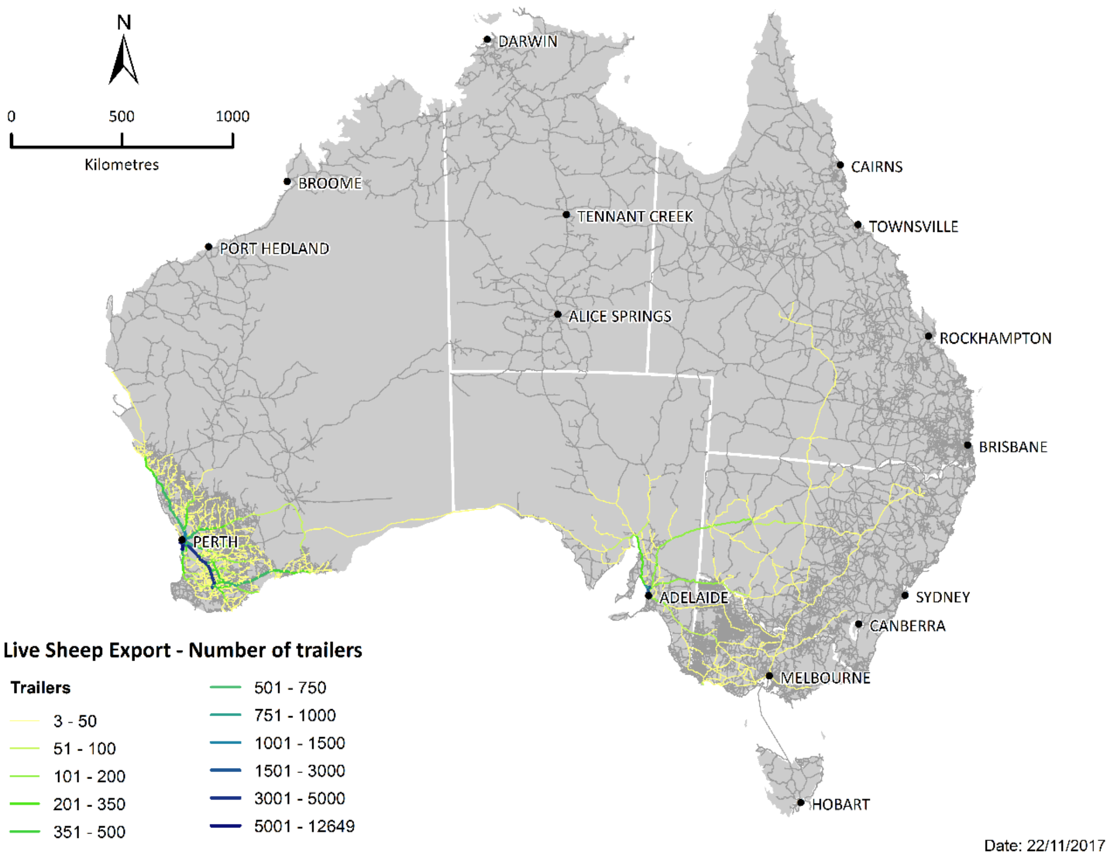

Fig. 2 Average number of vehicles per year for sheep only. Includes trips from farm to export depot and export depot to port.

4.2.3 Cattle ship movements to markets

Cattle movements for 2016 were collated and used to create a density map detailing the distribution of the export trade internationally (Fig. 3). The map provides an overview of the trading partners and the relative size of their market in 2016, highlighting that Indonesia is Australia's largest export cattle market and Vietnam and China are also significant markets. The map includes the average movements within Australia from producer to export depot and port.

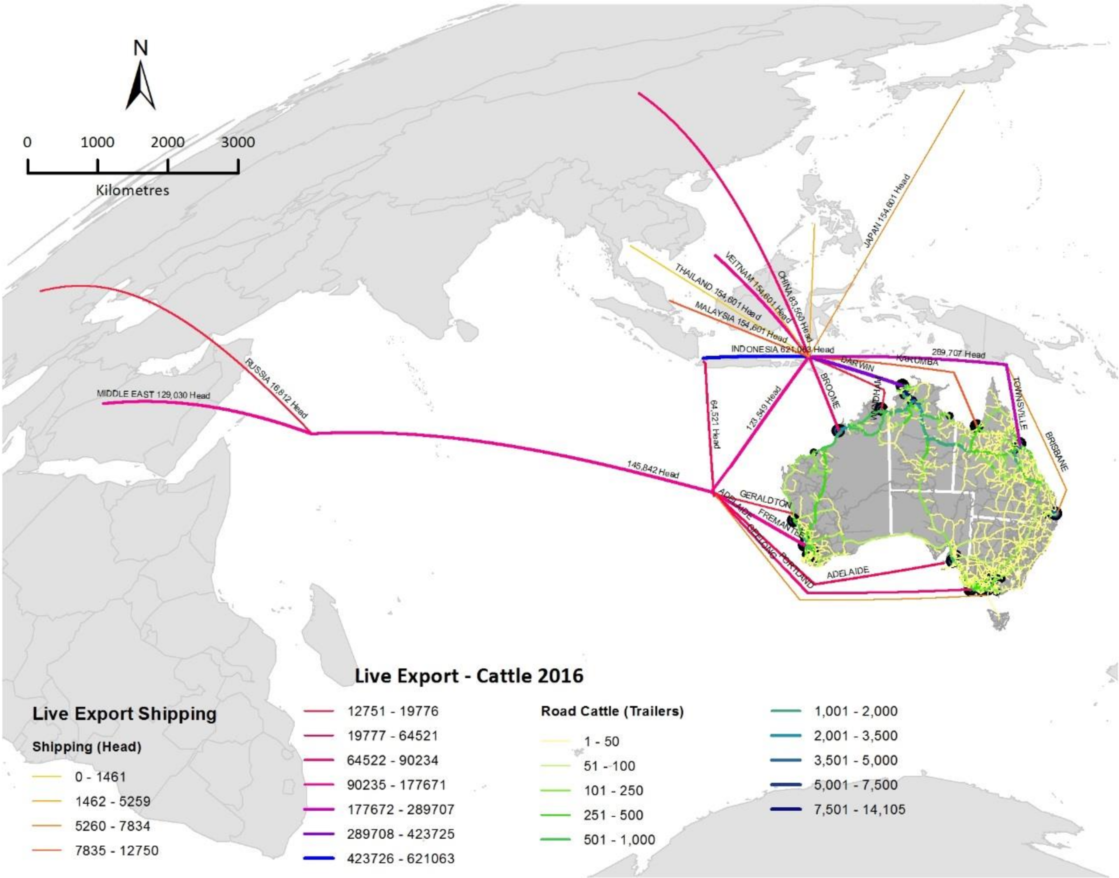

Fig. 3 Number of cattle exported from Australian ports in 2016. Includes average vehicle trips within Australia from farm to export depot and export depot to port.

Data providing live export movements for cattle indicating the port of origin and country of destination are summarised in Table 6 for years 2014–2017. The data for 2017 are not for the full year.

Table 6 Cattle exports from origin to destination ports 2014–2017.

Origin port	Destination country	Year Number of head			
		2014	2015	2016	2017
Adelaide	Indonesia	2,371	12,867	8,400	0
	China	0	0	3,914	0
	Bahrain	150	906	0	0
	Qatar	2,807	300	400	100
	Jordan	9,418	0	18,746	0
	Israel	13,785	30,054	0	0
	Kuwait	0	0	0	0
	Turkey	0	0	18,972	0
	Russia	22,138	15,141	0	0
Brisbane	Japan	8,039	10,199	6,208	4,197
Broome	Indonesia	96,702	79,526	73,633	26,774
	Malaysia	5,268	2,109	1,637	0
	Vietnam	4,400	40,006	14,964	13,201
Darwin	Indonesia	488,910	402,612	378,894	141,379
	Malaysia	9,913	3,903	2,240	2,936
	Vietnam	28,971	67,797	35,161	6,601
	Israel	4,315	0	0	0
	Brunei	5,526	2,220	4,449	0
	Borneo	3,171	3,405	1,520	1,236
	Thailand	0	9,110	1,461	0
	Philippines	2,744	5,050	0	0
Fremantle	Indonesia	23,857	31,632	47,025	8,925
	China	0	0	11,456	4,212
	Malaysia	4,984	2,959	5,009	0
	Vietnam	0	29,364	23,269	9,168
	Bahrain	450	306	0	0
	Qatar	300	1,050	1,130	969
	Jordan	54,461	30,473	27,490	9,782
	Israel	5,467	15,493	32,412	0
	Dubai	627	0	1,233	0
	Thailand	0	1,352	0	0
	Turkey	2,295	0	28,647	0
	Mauritius	5,714	1,903	0	0
Geelong	China	16,909	15,661	7,834	7,774
Geraldton	Indonesia	10,352	9,477	9,096	2,023
	Vietnam	3,313	10,125	10,012	0
	Brunei	0	0	0	1,456
Karumba	Indonesia	19,591	12,849	9,512	0
	Malaysia	0	1,650	3,238	0
	Vietnam	2,829	1,524	0	0
	Brunei	0	1,099	0	0

Mourilyan	Vietnam	1,396	0	0	0
Portland	China	81,152	65,361	60,356	13,679
	Malaysia	3,430	0	0	0
	Vietnam	0	2,100	1,699	1,787
	Israel	0	4,185	0	0
	Pakistan	0	3,842	0	4,065
	Russia	15,788	17,152	16,812	0
Townsville	Indonesia	217,051	157,718	139,248	82,779
	Malaysia	0	3,465	0	0
	Vietnam	27,130	109,219	69,496	12,804
	Philippines	0	0	5,259	0
Wyndham	Indonesia	25,596	30,739	19,776	12,115
	Vietnam	3,169	3,970	0	0
TOTAL		1,234,489	1,249,873	1,100,608	367,962

4.2.4 Sheep ship movements to markets

Sheep movements for 2016 were collated and used to create a density map detailing the distribution of the export trade internationally (Fig. 4). The map provides an overview of the trading partners and the relative size of their market in 2016, highlighting that the Middle East is Australia's largest export sheep market. The map also includes the average movements within Australia from producer to export depot and port.

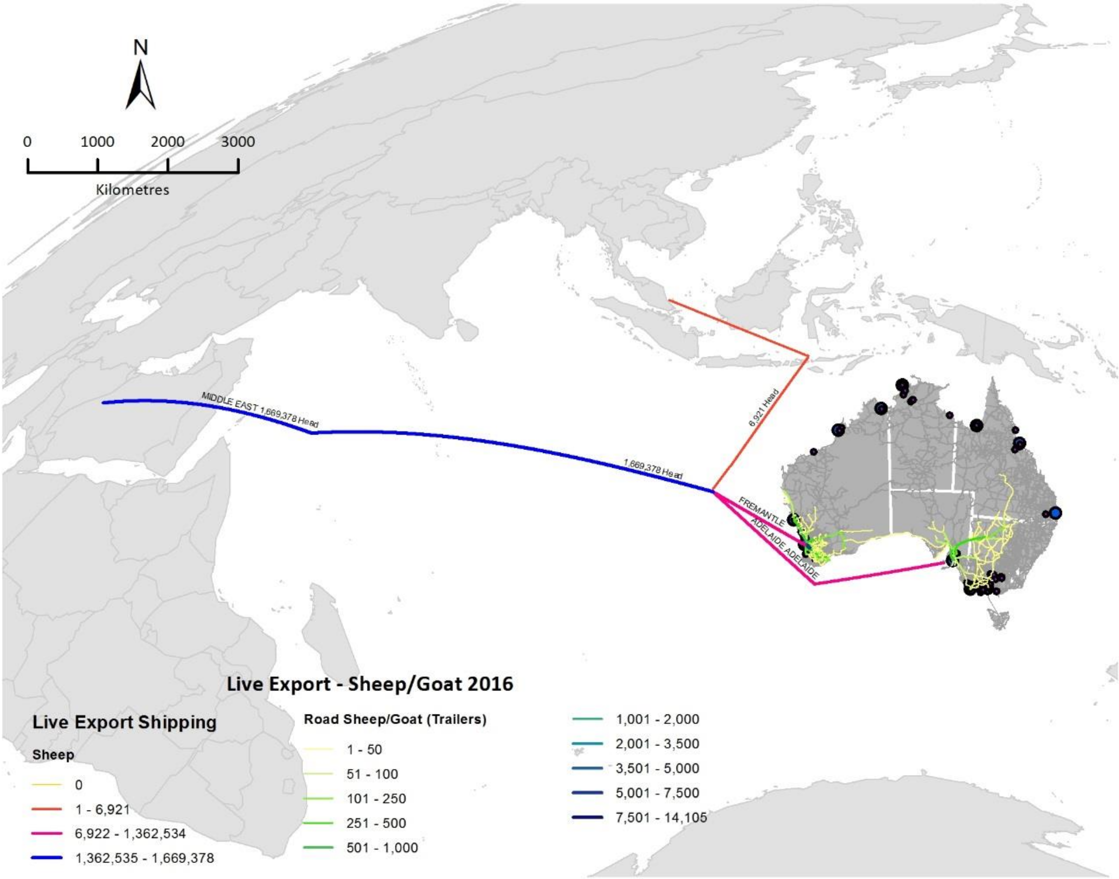

Fig. 4 Number of sheep/goats exported form Australian ports in 2016. Includes average vehicle trips within Australia from farm to export depot and export depot to port.

Data providing live export movements for sheep and goats indicating the port of origin and country of destination are summarised in Table 7 for years 2014–2017. The data for 2017 are not for the full year.

Table 7 Sheep exports from origin to destination ports 2014–2017.

Origin port	Destination country	Year Number of Head			
		2014	2015	2016	2017
Adelaide	Indonesia	0	800	0	0
	Bahrain	142,544	71,756	0	0
	Qatar	341,252	271,224	161,473	300,896
	Jordan	56,426	0	101,682	0
	Israel	23,906	24,051	0	0
	Kuwait	0	0	60,112	0
Fremantle	Indonesia	6,603	7,658	9,502	0
	Malaysia	1,041	0	6,921	0
	Bahrain	593,126	824,987	0	0
	Qatar	254,709	398,312	958,128	293,497
	Jordan	311,414	160,390	130,815	36,857
	Israel	0	19,562	40,377	0
	Dubai	220,717	154,050	137,625	0
	Kuwait	61,832	0	79,166	0
Geraldton	Indonesia	1,388	0	0	0
Portland	Bahrain	71,864	0	0	0
TOTAL		2,086,822	1,932,790	1,685,801	631,250

4.3 Scenario development and testing

4.3.1 Scenario development

The baseline analysis and the categories of capacity constraints and operational inefficiencies were used to find possible scenarios for testing with TraNSIT. A number of scenarios were identified for testing. A detailed record of the discussions is provided in Appendix **Error! Reference source not found.**, and summarised by category in Table 8 below.

Table 8 Scenarios for testing in TraNSIT.

Categories	Scenario
Physical infrastructure constraints	Cape York roads – improving access to Townsville and Weipa. Improving access on all roads currently constrained. All weather access to roads in the north affected by wet season. Darwin to Townsville via the Savanna Way. Upgrade of the Buntine Highway where there is only single lane access needing widening or unsealed needing sealing. Barkly Stock Route sealing. Tablelands Highway between Cape Crawford and Barkly Stock Route. Plenty Highway upgrade. Road through Labelle and Bachelor (Litchfield Park access road) and the Finniss River bridge. Gibb River Road improvement to improve access to Port of Broome. Road access on the Barkly Tableland. Southern ports have restricted access for B-double or multiple deck trucks. Restrictions of B-doubles at Sydney Airport and Sydney Airport curfew.

	Limit on the number of registered premises in general and specifically near Townsville and Darwin, sheep yards near Fremantle.[A] Truck movements from registered premises to Fremantle Port, limit on truck size to C-trains (7 decks) and pinch points on Kwinana Freeway near Cockburn Gate, Stirling Highway and Swan River bridges. Road train access to Muchea saleyards. Near Wooben on Great Northern Highway. Jarrahdale Road through Armadale (WA) is limited to B-doubles and needs upgrading. Sections of Mundijong Road have been shut to truck access. Road from SA border to Portland is in poor condition in parts, especially Mount Gambier to Portland. Yorkey Crossing needs to be upgraded with limitations on the Eyre Highway bridge across the top of the Spencer Gulf through Port Augusta. Dedicated breakdown and cross loading facilities for movements off the Eyre Peninsula.
Operational constraints on adequate infrastructure	Road access restriction on triple road trains. Wash down facilities inadequate in south-west WA. Loading gear at ports in WA.[A] Curfew on Cape Nelson Road near Portland.
Regulatory inefficiencies and duplication (and new regulations)	Northern Australian biosecurity issues especially bluetongue virus. Most complex and comprehensive regulations in the world, add costs. Lack of consistency in inspections between different DAWR offices across Australia. Costs of Australian government biosecurity inspections increasing. Different state government charges and times for property of origin certification (e.g. Victoria 5 days, WA same day). Volumetric loading in the NT. Victorian roads are restricted to B-doubles. Changes to the animal identification in Victoria will stop sheep exports from Portland, will be out of Adelaide and WA ports only.
Port infrastructure and operational constraints	Karumba Port, lack of dredging limits the vessel size.[B] Tidal ports have a window of opportunity to load. Berthing priority, for example Geraldton Port prioritises bulk cargo and Townsville can have limited access. Navy will always get access. New port options such as Port Alma. Fremantle Port upgrade and the restrictions of access of the multi-user berth. Westport expansion plans for Fremantle Port. Movement to the Outer Harbour in Cockburn Sound. Rowley and Anktell roads will be the primary roads servicing the Outer Harbour. Portland sheep loading infrastructure and the use of NLIS tag of sheep in Victoria making it no longer possible to export from there, now Adelaide the only option. Comparative post costs required and understanding of potential 'additional' costs for inputs such as water, congestion charges. Port Adelaide operates on first in first served basis and no priority given to live export ships. Jakarta Port is congested and landside traffic very congested. Port Adelaide using multi-user berth, investment in dedicated facilities would increase use.[A]
Input cost and operational inefficiencies	Stevedore costs and additional costs for loading out of hours.[A] Fodder costs, quality and availability.[A] Fodder loading equipment.[A] Bunker fuels.[A]

[A] Commercial consideration

[B] Dredging of Kurumba Port to a depth of 3.2 m announced by Queensland Minister of Transport and Main Roads (www.statements.qld.gov.au/Statement/2018/3/22/north-west-queenslanders-sure-to-dig-new-karumba-dredge-works)

Two approaches to analysing the infrastructure constraints were discussed in the consultation:

- The ideal scenario, where road access is always unrestricted (i.e. all roads are sealed providing year-round access and no need to 'breakdown' high productivity trucks) was discussed by stakeholders as a way to identify where the 'best' gains could be made. This would show the cheapest possible transport cost and shortest transport time, and therefore highlight where there currently are constraints.
- A number of production regions were also highlighted where any improvement in road access and access onto properties would result in time and costs savings: Cape York; Gulf region between Normanton and Cloncurry; north Kimberley; north-west and north-east of Tennant Creek; Victoria River District; and the northern part of the Flinders, Gilbert and Norman catchments.

However, stakeholders weren't able to identify specific or stand out road issues where improvements could be analysed. To account for the 'ideal' and 'geographic/production region' scenarios, a pinch point analysis was undertaken that analysed identified road constraints (from Table 8 and CSIRO, 2016).

Stakeholders in Queensland noted that some of the barriers and constraints are commercial considerations and that the private sector will find a solution when there is a compelling need for it. Analysis of these would not be relevant to this study, and their consideration would diminish and undermine the findings of this study. As such we have not included in the analysis any constraints that could or would be resolved by private sector providers once there is a business opportunity.

Port operating constraints and costs were highlighted by a number of stakeholders. The challenges included accounting for tidal conditions that restrict loading times (e.g. Port of Broome); the lack of prioritisation of live export ships over other general freight ships, especially where general purpose berths are used; and stevedore and demurrage costs. It wasn't possible within the scope of this study to develop a port loading and costing model, and the small number of ship movements (relative to all ship movements for all general and bulk freight) would limit the reliability of that model and its applicability. A port costing model will be developed in the near future and the stakeholders consulted here will be referenced for data and checking the applicability of the model to their operations.

4.3.2 Scenario testing

4.3.2.1 The ideal scenario

For this analysis an understanding of the breakdown of movements by region was required. The movements between north and south were defined as all properties of origin north of 23.5° latitude. This shows that most cattle movements from property to export yards are within the same region, with 97% of cattle moving to a northern port from northern properties, and 86% of cattle moving to a southern port from southern properties. There are some that move north from southern properties and some heading south from the north. All movements from export yard to port were local. For southern ports, 14% of the cattle were sourced from northern properties. Of the 1490 properties where cattle were sourced, only 82 moved cattle both north and south, and there were 32 of these not moving any north but around 2000 head south in the wet season.

Fig. 5 shows the movement of cattle across the year. There is a peak in the dry season from March to April, tapering to September for the northern properties to northern export yards. The wet season drop off indicates a constraint of about 40,000 head per month for the December, January and February period. However, the challenge in interpreting these data is that there are still some cattle moving to northern ports during this period, so although there is a reduction the movement of cattle doesn't completely stop. The movement from southern properties to the southern export yards is consistent all year round. Sheep movements were also assessed, with 2400 sheep, or 0.1% of exports, moving from the north to export from southern ports.

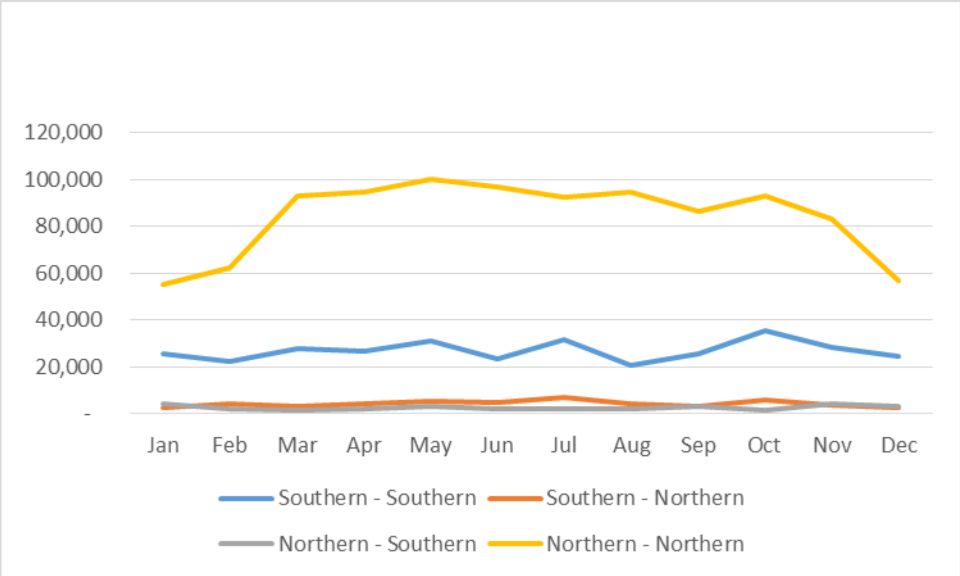

Fig. 5 Regional cattle (number of head) movements to export yards by month.

4.3.2.2 Road upgrades in northern Australia

As part of the Beef Roads project (CSIRO, 2016), 60 proposed infrastructure changes including sealing gravel roads, upgrading road access to allow higher productivity vehicles, upgrading bridges to reduce inaccessibility from flooding, and upgrading intersection access to key facilities were prioritised and assessed through TraNSIT to compare the savings to the northern Australian beef industry (**Fig. 6**). Many of those scenarios have subsequently had funding commitments (and as such not re-assessed here) and not all of those recommended would impact livestock export transport. Consulted stakeholders recommended re-analysing road upgrades proposed in the Beef Roads project that were expected to result in savings in transport costs to the live export industry. The analysis for the Beef Roads project provided the following results in terms of savings. The below list summarises the relevant results.

- Cape York roads – improving access to Townsville and Weipa – Analysis of sealing the Peninsular Development Road was expected to achieve savings of $1.44/head. This was for the wider industry but the estimates are likely to be able to be applied to the live export industry. Currently approximately $200 million funding has been allocated to carry out sealing along this road.
- Darwin to Townsville via the Savanna Way – Sealing of the Doomadgee to Burketown section of the Savannah Way showed potential savings of $1.14/head.
- Upgrade of the Buntine Highway where there is only single lane access needing widening or unsealed road needing sealing. The Buntine Highway has a planned expenditure of $140

million. Analysis during the Beef Roads modelling showed savings of between $0.81 to $2.72 and up to $5.39/head depending on the sections targeted.

- Road access on the Barkly Tableland including Barkly Stock Route sealing ($0.56/head) sealing the Barkly Tableland Highway between Cape Crawford and Barkly Stock Route ($0.41/head)
- Plenty Highway upgrade, a number of scenarios were modelled indicating savings of between $1.54 to 3.12/head.
- Gibb River Road improvement to improve access to Port of Broome. This scenario was not modelled; however, modelling of staging at Port of Broome is expected to result in savings of $0.98/head.

A number of these pinch points are being addressed by the Northern Australia Beef Roads Program or the Northern Australia Roads Program. (www.investment.infrastructure.gov.au/infrastructure_investment/northern_australia_beef_roads.aspx).

4.3.2.3 Pinch point analysis

As part of the modelling a pinch point analysis was completed. The pinch point analysis was undertaken to reveal road segments that may be constraining the movement of livestock but hadn't been identified by stakeholders or in previous assessments. This is an analysis where the roads carrying relatively large freight task (i.e. trailer numbers) but the roads with less than a full seal are identified for closer review. This analysis used a cut-off of the 75th percentile of freight task and any road where there was no seal or less than a full seal. The analysis was completed using the beef roads scenario sections as a starting point and analysis looked specifically where livestock for export were likely to be moved.

Fig. 7, 8, 9, and 10 shows the outcome of the analysis, which indicates where additional analysis of the road conditions is required to assess the upgrades required.

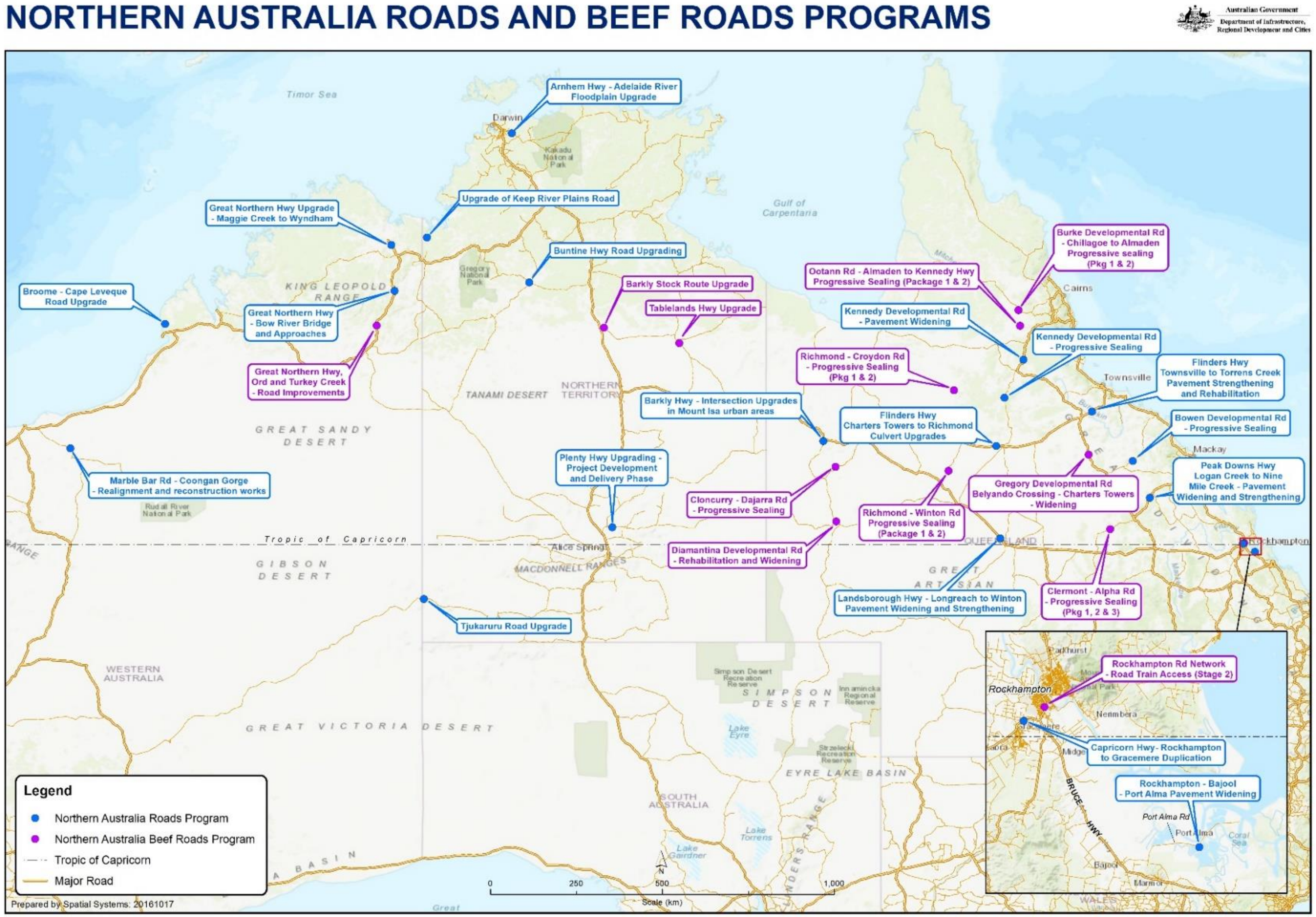

Fig. 6 Road improvements listed for the Northern Australia Beef Roads Program.

(Source: www.investment.infrastructure.gov.au/infrastructure_investment/northern_australia_beef_roads.aspx)

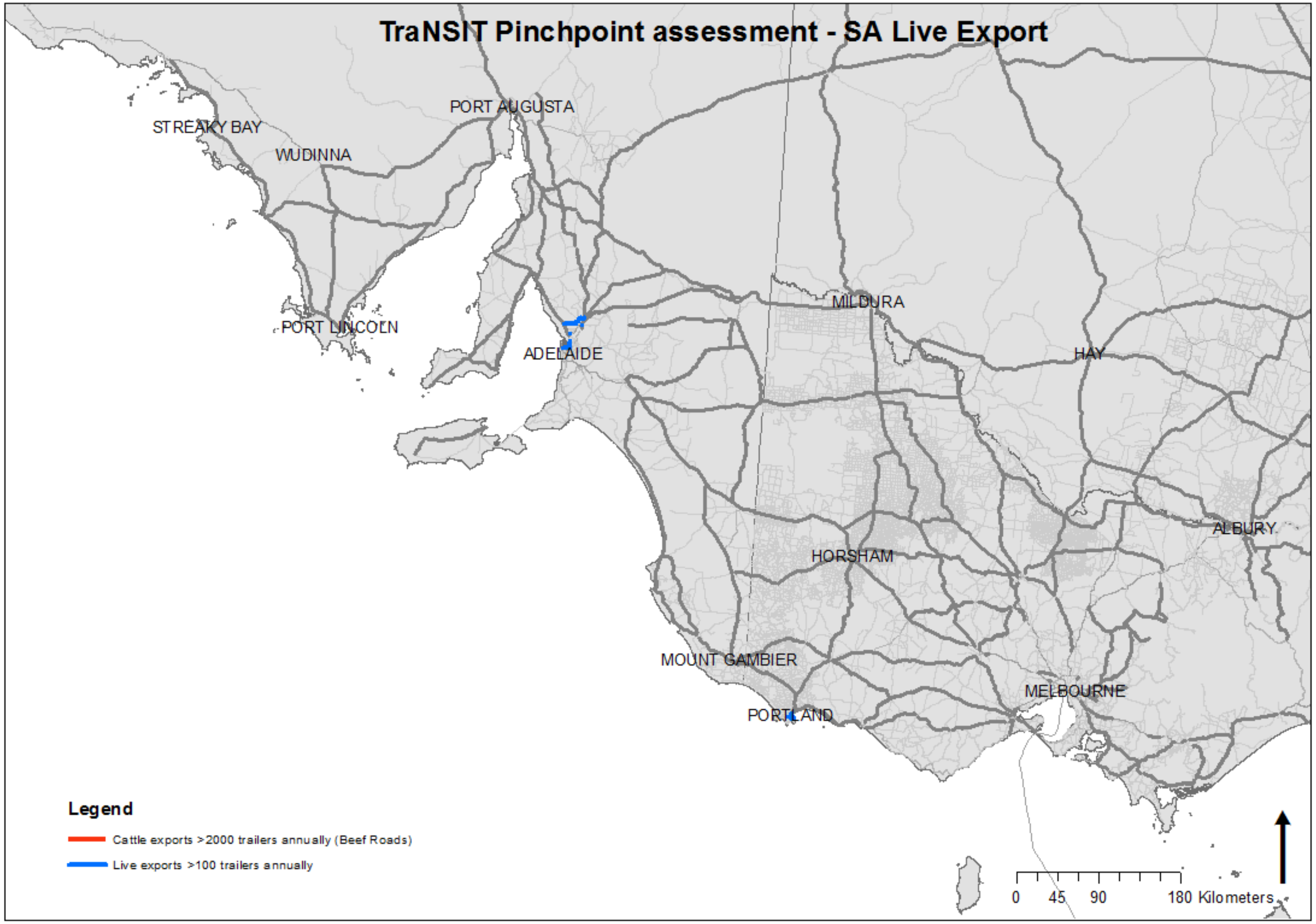

Fig. 7 Pinch point analysis of South Australia beef roads to identify constrained road sections.

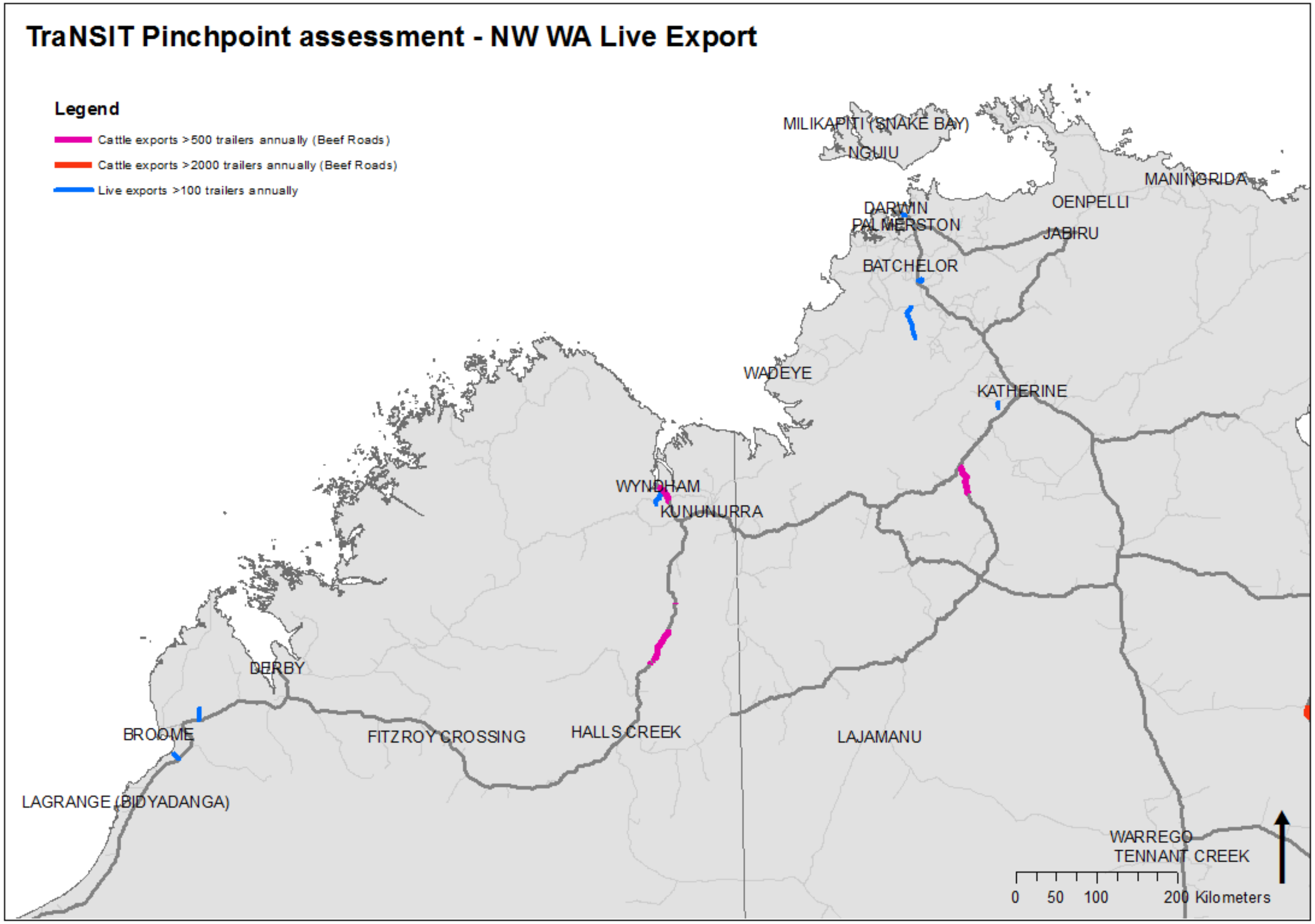

Fig. 8 Pinch point analysis of north west Western Australia beef roads to identify constrained road sections.

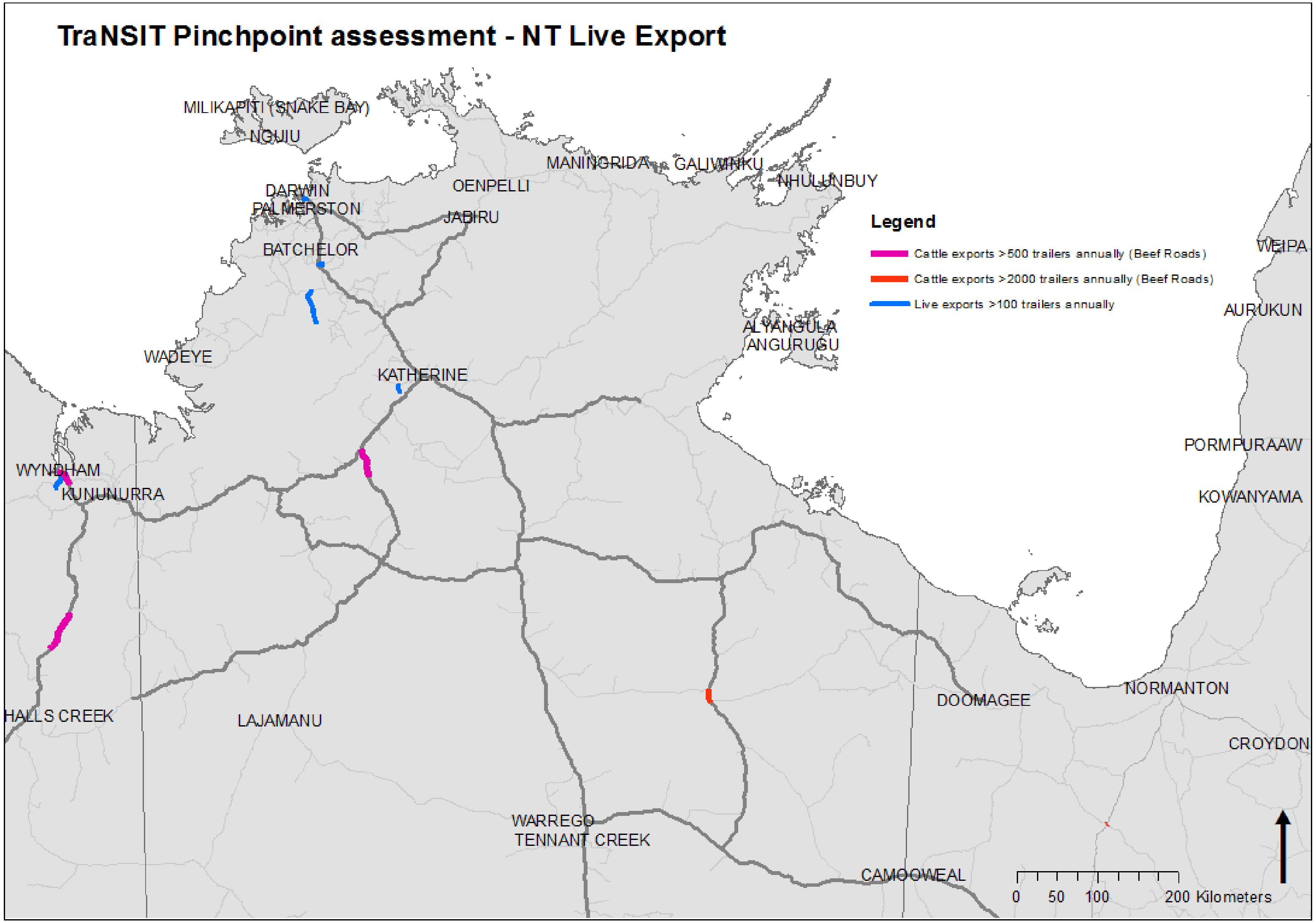

Fig. 8 Pinch point analysis of north west Western Australia beef roads to identify constrained road sections.

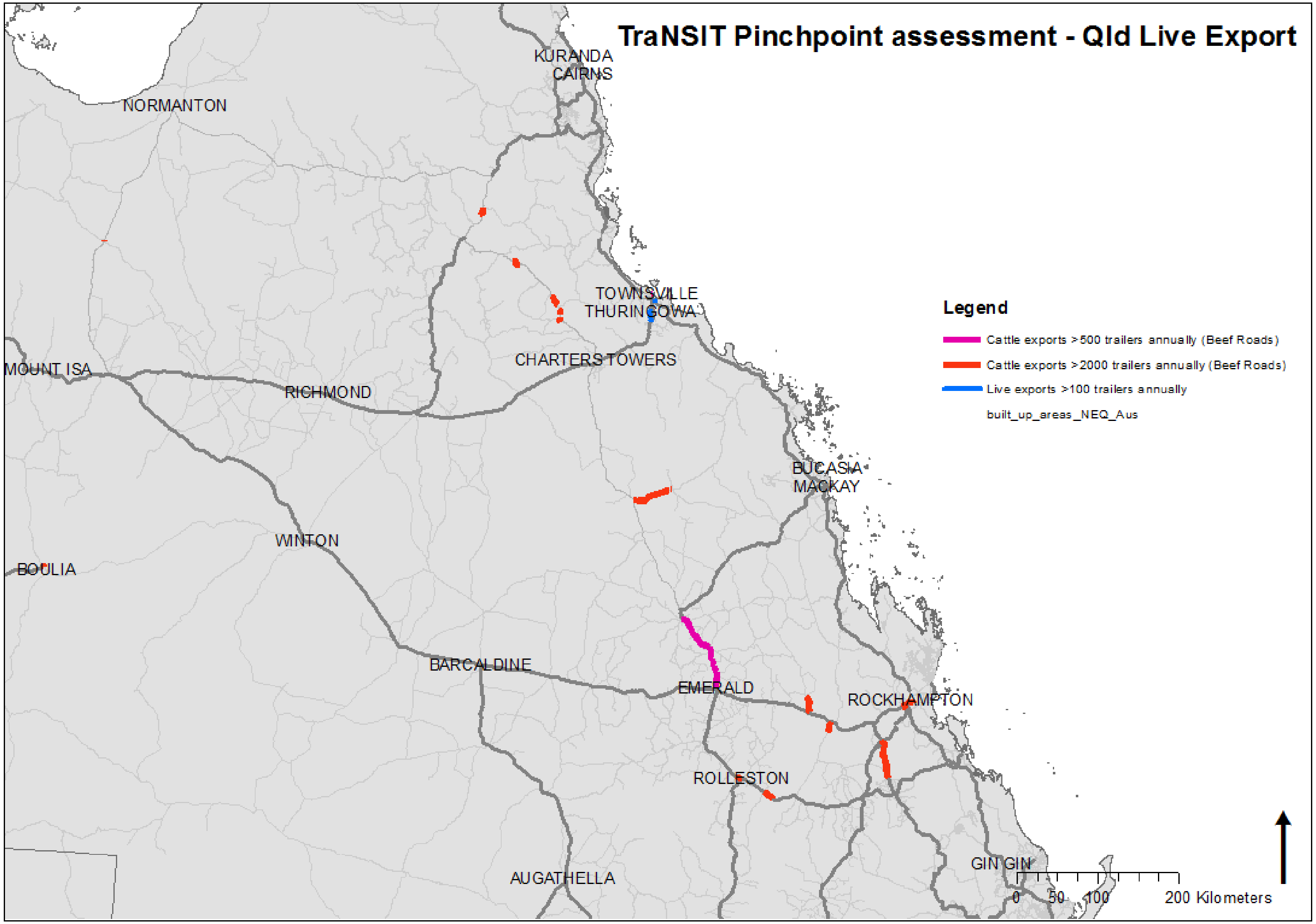

Fig. 9 Pinch point analysis of Queensland beef roads to identify constrained road sections.

4.3.2.4 Reroute around Fremantle to new port facilities in the Outer Harbour at Kwinana

This scenario was run to understand the impact on transport costs and freight flows from redirecting live exports from the Inner Harbour at Fremantle to the Outer Harbour at Kwinana. Three scenarios were modelled:

- existing supply chain through Fremantle Port (Fig. 10)
- changed supply chain where exports were redirected to new port facilities at Kwinana (Fig. 11)
- upgraded access to the new port facilities at Kwinana along Thompson Road allowing RAV Category 6 routes (A-double/modular B-triple combinations) (Fig. 10).

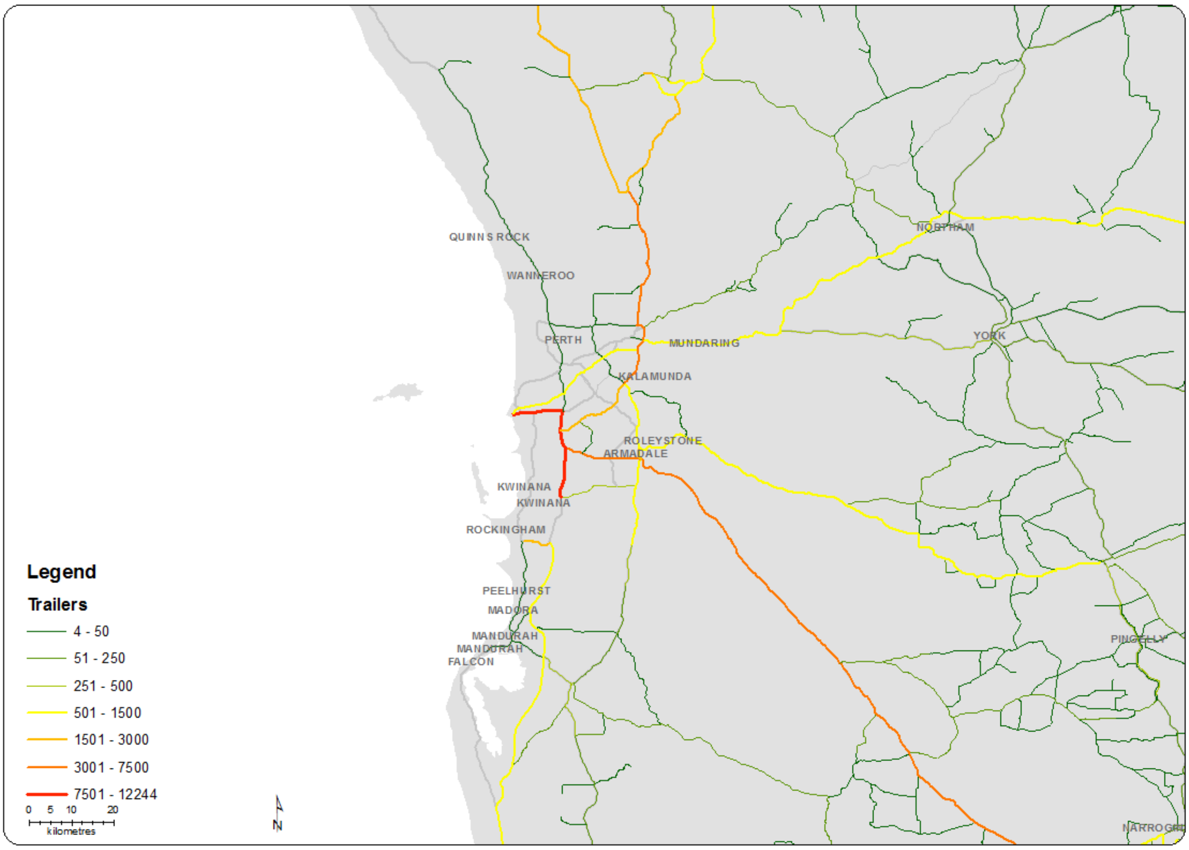

Fig. 10 Fremantle Port live export existing supply chain.

Approximately 36,000 head of cattle and 1.3 million head of sheep benefit from the redirection to new port facilities at Kwinana. The savings are in the last leg of the movement from the export depot to the port and average $1.20 for cattle and $0.40 per head for sheep. For the current annual throughput of 150,000 head of cattle and 1.6 million head of sheep the total expected transport costs are $19,619,000 (cattle – $7,077,000 and sheep – $12,542,000). The redirection would see the costs reduce to $19,056,000 (cattle – $7,034,000 and sheep – $12,022,000).

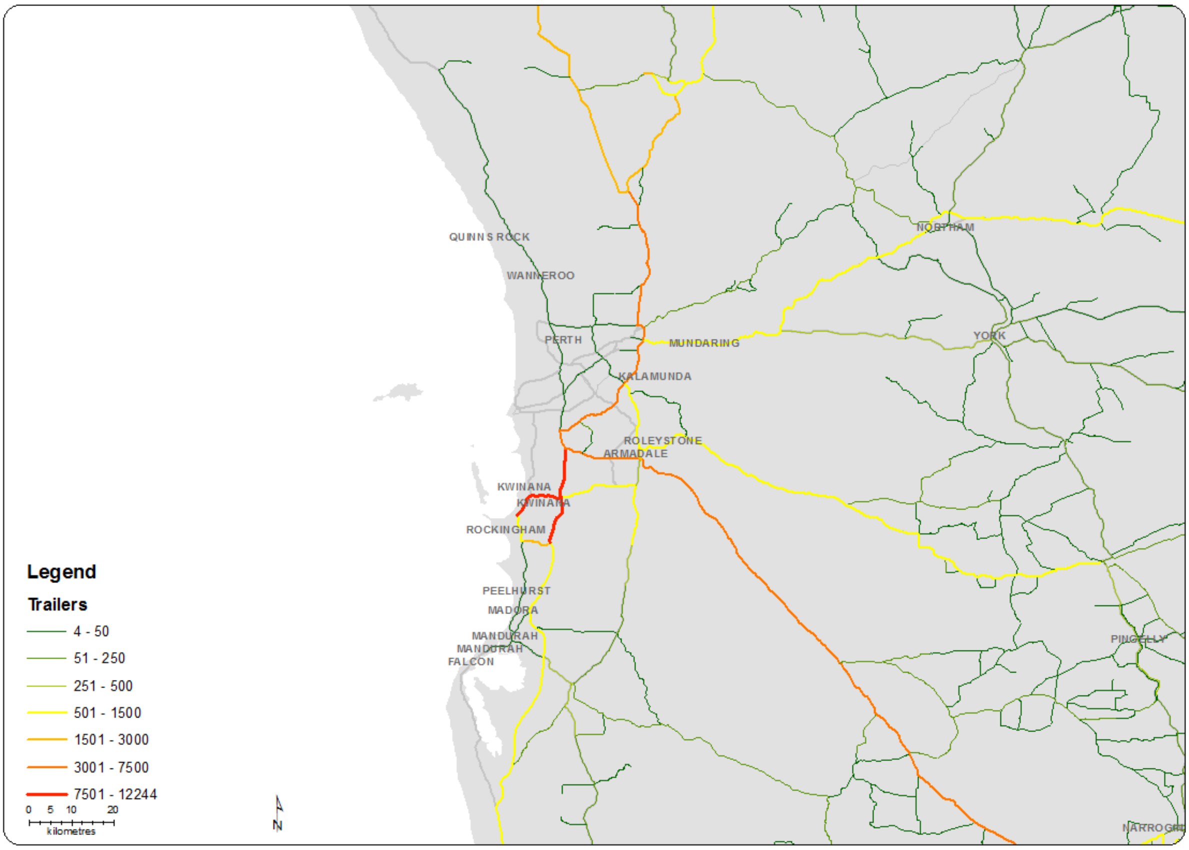

Fig. 11 Live export redirected new port facilities at Kwinana.

If the access to new port facilities at Kwinana Port were to allow higher capacity vehicles the extra savings were much less, affecting fewer movements. Approximately 213,000 head of sheep and 8600 head of cattle received extra savings of $0.50 per head on the trip from property to export depot on to port, largely due to the ability to run a higher capacity vehicle for the length of the trip.

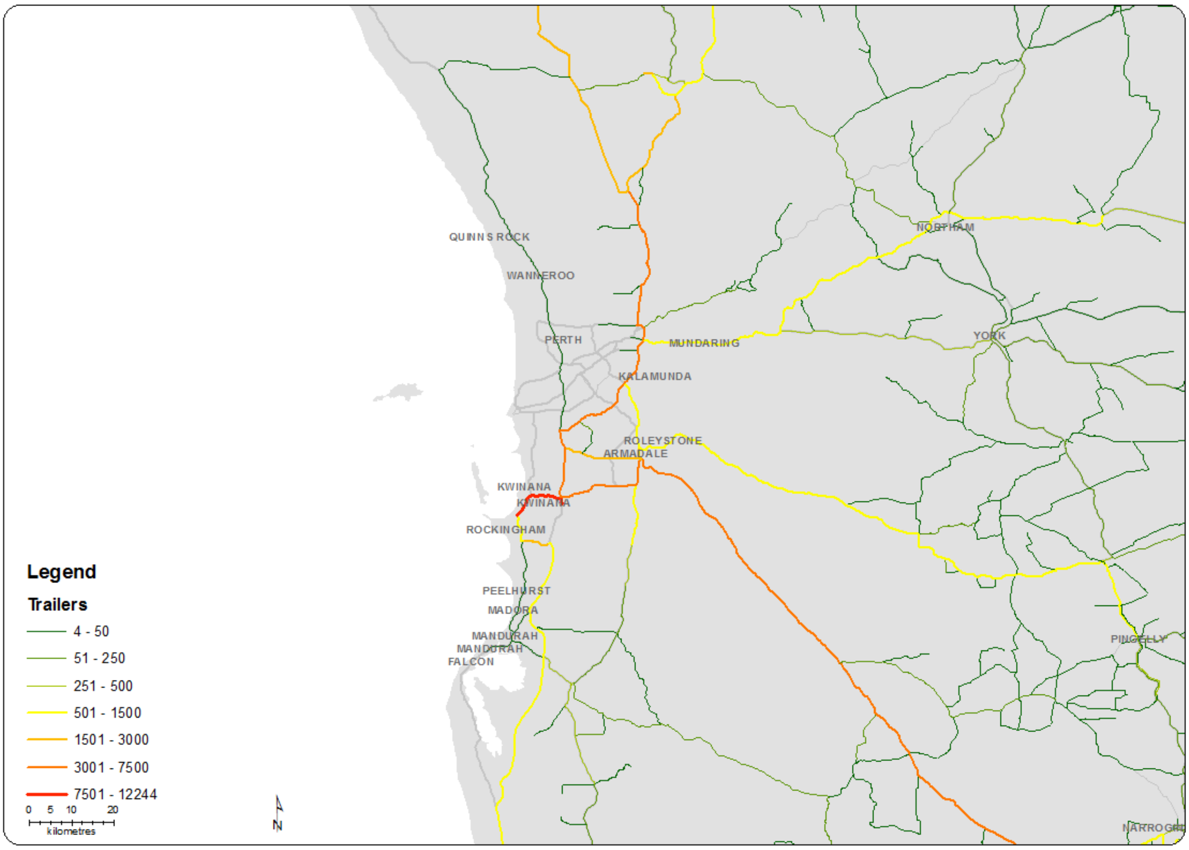

Fig. 12 Live export redirected through new port facilities at Kwinana with higher capacity transport access.

4.3.2.5 Redirect livestock away from Portland

This scenario looks at the impact of redirecting existing export movements from Portland to Port Adelaide. Feedback indicated that Portland sheep loading infrastructure and the use of NLIS tagging of sheep in Victoria will make it no longer possible to export from Portland, and Adelaide may be the only option. The results showed that for the 25,700 head of sheep exported from Port of Portland, the result of the redirection was significant, increasing the average transport distance from 80 km to 735 km. This then increased the time on board the trucks for the animals from about 1 hour to approximately 8 ½ hours, adding to driver fatigue and truck wear and tear, as well as increasing the potential for animal welfare issues. The cost per head also increased from $1.42 to $12.49.

4.3.2.6 Upgrade highway between Portland and Mount Gambier

Stakeholders had indicated the highway between Mount Gambier and Portland was poor, and that the road has many potholes, requiring significant attention (Fig. 13). Based on this feedback, a scenario was run where the highway was improved to a standard where the livestock could be transported safely at the expected speed for this class of road.

Fig. 13 Road upgrade from Mount Gambier to Portland.

The results showed that approximately 180 of the 7436 distinct export routes use at least some of this highway. These movements carry approximately 48,900 head of cattle and 9900 head of sheep. The savings accrued for beef of the road upgrade were $1.34 head, while for sheep the savings were $0.42, totalling to a projected total annual savings of $71,824. Further, the average time saved in travel, while seemingly small at 20 minutes, would result in many of the trips reduced below the driver fatigue threshold, which would save extra time for the livestock on board the trailers and reduce the potential for animal welfare issues.

4.3.2.7 Regulatory

Scenarios run on livestock movements included one where all roads were sealed but access for heavy vehicles remained constrained as to where higher capacity vehicles were permitted across the network. These analyses were run for all networks across the country and showed that while transport costs can be reduced through sealing, significant savings resulting from reduced maintenance costs and reduced fatigue management costs due to higher speeds and reduced travel time. Flow-on effects would be expected in terms of animal welfare and product quality as a result. While these savings estimates were informative it was estimated from an extreme modelling example where there were no vehicle access restrictions. The savings from more efficient vehicles can be up to 10 times that of sealing alone, demonstrating the value of identifying freight paths that are able to carry higher efficiency vehicles. The following scenario was to allow access of Type 1 road trains for all B-doubles to southern ports and export yards and for all roads in Victoria. Table 9 shows the breakdown of the savings.

Table 9 Potential productivity improvements in transport costs from higher capacity access to port.

State	Beef		Sheep/goats	
	Property to export yard	Export yard to port	Property to export yard	Export yard to port
SA	–$3.15	0	–$0.74	–$0.24
VIC	–$2.72	–$0.73	–$1.20	0
WA	–$1.84	–$0.99	–$0.42	–$0.15

4.3.2.8 Sydney Airport access

Another scenario discussed was the effect of the curfew for livestock to Sydney Airport. The modelling indicates a movement of a plane load of cattle (assumed 240 head) to Sydney Airport from a location approximately 100 km west would require four B-double vehicles based on 60 head per load and cost a total of $1190 and take approximately 90 minutes' drive time. If the curfew was not made the cattle would need to be returned and re-dispatched, costing a further $1190 not including rest time or driver delays due to the process. This is at a cost of $10/head, with the cost of the new dispatch to still be included.

4.3.2.9 Biosecurity

The implication of the northern Australian biosecurity issues, especially around bluetongue virus, was raised. This concern relates to the agreed cattle protocol that uses the presence or absence of the bluetongue virus in different regions of Australia and China to differentiate levels of risk management. Table 10 below shows the costs for moving cattle to port via an export depot for the states.

Table 10 Cattle transport costs to port.

Cattle transport costs	To export depot	To port
NT	$36.71	$5.82
QLD	$21.70	$5.89
SA	$41.29	0
VIC	$27.88	$6.74
WA	$33.26	$7.21

The table shows that the transport costs for most are similar, with Victoria and Queensland costing less than other states; however, the differential in cost will come from shipping itself (where northern ports have shorter sailing times to China). The time savings in shipping costs are likely to be in the order of 3–4 days, which would lead to significant savings in total transport costs, potentially outweighing any ground-based bottleneck saving. Efforts towards improving the export arrangements for animals in the bluetongue zone would be expected to have substantial benefits in terms of costs and marketing opportunities. Given port and ship costing models are not yet available, it wasn't possible, or within the scope of this project, to quantify the benefits that are likely.

4.3.3 Receiving markets

4.3.3.1 Indonesia

The change to permits for imports of cattle to Indonesia, from a quarterly application to an annual application process, has led to greater market certainty. However, with that change were also other changes, including the removal of weight restrictions, and changing the requirement for the number of breeders and feeders to at least 1:5 (head) for businessmen and at least 1:10 for farmer cooperatives and farmer groups (Ministry of Agriculture Regulation Number 49/Permentan/PK.440/10/2016 concerning Importation of Ruminants into Indonesia Territory).

Capacity constraints and bottlenecks are well documented in Indonesia, for all agricultural sectors, but are especially acute for the movement of cattle from Port of Tanjung Priok to nearby feedlots through greater Jakarta. The process flow of cattle disembarkation was tracked during a field visit in June 2017. This involved timing and observing offloading, following the trucking path from port to feedlot, and collecting truck utilisation data. A process flow model of the operation is represented in Fig. 14. The model demonstrated the impact of different interventions on total dispatch time. Currently, total dispatch time is approximately 36.5 hours. If the truck fleet is upgraded from its current capacity of 13 head to 17 head per vehicle, there is a 4.5-hour savings in total dispatch time. An investment in improving infrastructure, in this case repairing a damaged bridge (which is on the preferred route between the port and feedlot), reduces the trip time per truck by 2 hours (and most likely improves animal welfare) and there is an overall saving in dispatch time of 10 hours. But by far the greatest time savings occur if there are sufficient trucks in the fleet available to load. If the number of available trucks is doubled, this results in the greatest savings in dispatch time, and is the cheapest of the modelled interventions.

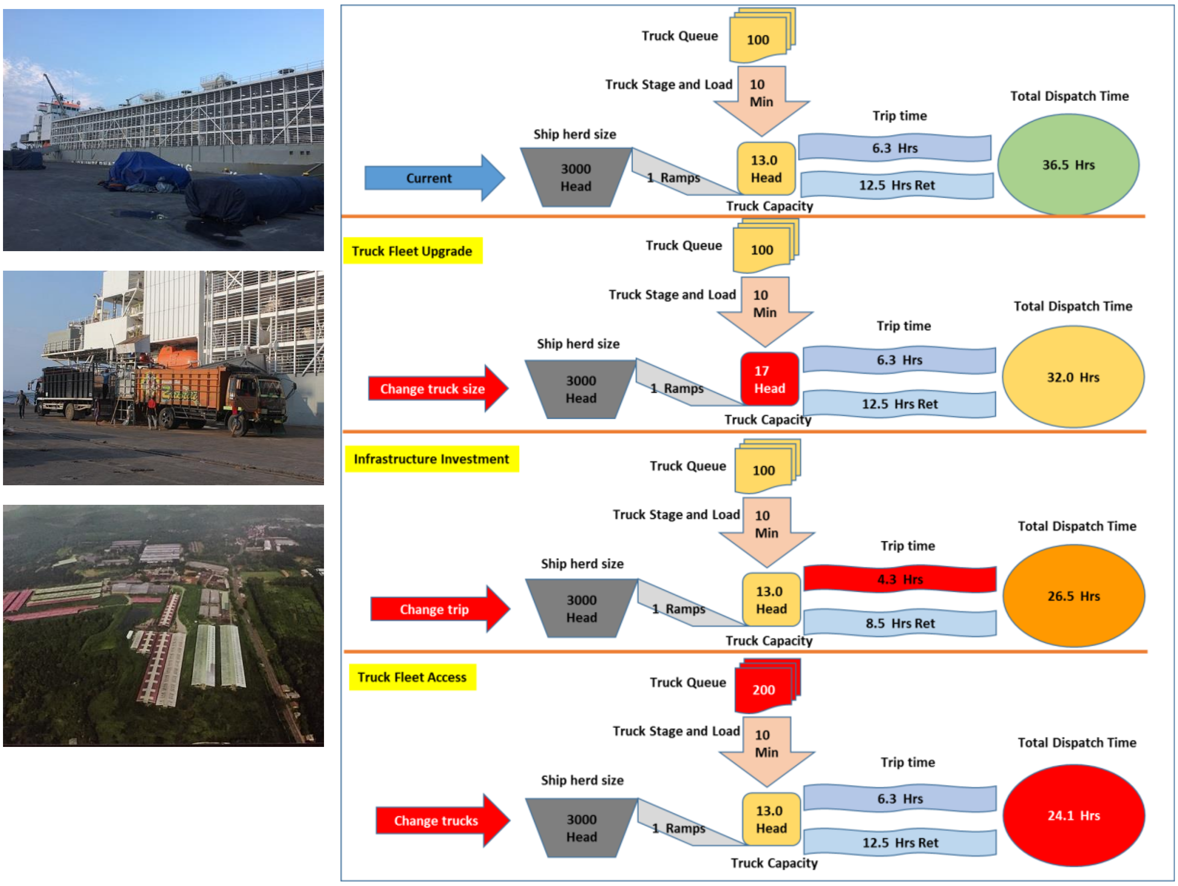

Fig. 14 Illustration of investment options for a case study of livestock transport from Port of Jakarta to a feedlot near Cianjur. A comparison is made between upgrading the truck fleet versus fixing a bridge to provide a faster trip to the feedlot.

The changing dates of Ramadan will cause issues for cattle access for the next 5 years. There is a need for importers and exporters to consider holding yards and forward selling into Indonesia over the next few years (see Section 4.3.2.1.) There is a real logistical challenge with Ramadan, and there might be constraints around how and where animals will be ‘stored’.

4.3.3.2 Middle East

Discharging a livestock vessel in the Middle East can be challenging. Numerous factors must be aligned to achieve a successful, effective and efficient discharge. Environmental factors and seasonal conditions can be testing for both the personnel discharging the livestock and livestock being discharged. A fast and smooth discharge is fundamental to ensuring a good animal welfare outcome is achieved. Generally, the inefficiencies and bottlenecks at discharges include:

- design fault of infrastructure such as poorly designed discharge platforms with stevedores poorly positioned to promote positive livestock flow, and vessel ramps too wide, allowing small stock to continually turn around
- method of joining vessel ramp to discharge platform requires constant monitoring and adjustment with a forklift, delaying discharge

- Road curfews and prayer breaks causing long pauses, disruptions, and breaks not synchronised between parties involved in the discharge (vessel crew, importers, stevedores and port staff)
- limited number of trucks are available for discharge and lengthy travel times between the port and quarantine facilities
- not all receivers allow for more than one livestock race to be loaded simultaneously as they are wanting to control the counting of livestock. The truck must be loaded one deck at a time with no switching between trucks. This causes flow issues. The ideal situation to maintain positive livestock flow is for trucks to be loaded one deck at a time but switching between each truck once a deck is loaded to allow for the deck to be closed off and not lose livestock flow.

Discharges can extend over several days and as such fatigue sets in and the efficiency of operations declines, exacerbating the challenged listed above. Once a vessel has berthed the processes of discharge can be relatively smooth if all border clearances have been obtained. Due to the size of the vessels arriving in the Middle East, a short delay in gaining permission to discharge the livestock has a relatively small time impact compared with the total time it takes to discharge a ship. Shipments to the Middle East are generally undertaken by large vessels with in excess of 10,000 cattle and 60,000–70,000 sheep on board. Consequently, the large number of livestock results in a long discharge of several days. Any small inefficiency in the process of discharging the animals can result in a prolonged overall delay, and expense to the industry. It wasn't possible in the scope of this project to observe discharge in any of the Middle Eastern ports. In future, a process flow model (as presented in Fig. 14) could be undertaken for all major ports.

5 Discussion

The project was able to characterise the nature of the supply chains and the current constraints, bottlenecks and inefficiencies. Stakeholder consultation and TraNSIT modelling were used to quantify the bottlenecks in the supply chain. While there is a long list of issues, many of the identified constraints are commercial considerations and regulatory issues. Infrastructure constraints were identified on a number of road and port access areas where investments would improve the movement of livestock from property to export depot and then on to the export port. However, the small scale of the industry means it is unlikely that infrastructure investments would be made solely on the basis of savings to the industry, although it is unlikely these investments would only benefit the live export industry.

The project aimed to review and identify opportunities to improve live export supply chain efficiency and reduce capacity constraints. The project was successful in completing that task; however, there are very few obvious opportunities for investments in landside infrastructure that will have a significant impact. By far the greatest savings to the supply chain will come from increasing efficiency by focusing on securing and expanding access for high performance vehicles to ports and airports.

- The industry spent $43.9 million (2014–2016) on cattle movements from properties to export depots, with over half spent on the movements to depots servicing Darwin Port, and

$7.8 million in movements from export depot to port. Darwin and Townsville had the most cattle moving through the ports. There was about $10 million spent on the movement of sheep to export depots, and an additional $4 million on the movement from export depots to port (noting that there was only one year of data from Adelaide). Fremantle had the bulk of movements.

- Supply chains are long and fragmented and the sourcing of animals is geographical spread. Changes to ownership and a lack of vertical integration also leads to inefficiencies within supply chains, captured in this study by the observation that inefficiencies and bottlenecks are often 'caused somewhere else by someone else'. Another issue that arises from this fragmentation is that any benefits that might come from improving infrastructure along a supply chain may not benefit those who invest, so it is unlikely that an individual actor within the supply chains will invest in improvements in transport and logistics if it doesn't give them a market advantage or reduce costs, so it is unlikely that any one actor or business will invest, meaning that improvement will most likely only be funded through collective industry actions or by governments. This then leads to the challenges of this industry attracting funding from government over another industry.
- The small size of the industries will make it difficult to lobby for specific infrastructure investments. Despite the small scale, the industry is high profile and faces challenges in maintaining its social license to operate, which will also create a challenge in lobbying for regulatory reforms that would reduce inefficiencies.
- Some of the constraints identified by stakeholders are commercial considerations, which the private sector will resolve when there is a compelling business case to do so, and as such were not further analysed.
- There remain contradictory views on port constraints. In northern tidal ports there are obvious operational constraints when there is a mismatch between the scheduling of berthing and loading, but in a port such as Port of Broome there isn't competition for space. In busier ports, live export loading is on multi-user berths, and there are clearly issues with prioritisation of live export boats over other users. The challenge for the industry is how to 'lobby' for preferential access over other users when the income generated for port operators in low.
- The northern wet season lowers the number of cattle movements to northern ports but doesn't stop those movement entirely. Further investigations of market demand are suggested, but our simple initial analysis suggests an additional 40,000 head of cattle per month in the wet season could be exported if there was an investment in infrastructure that could stage and hold cattle in the wet season (that would otherwise not be able to be transported off properties). This would be dependent on market demand, but a possible indicator of market demand was the movement of about 2000 head to southern ports, which were sourced from properties that only exported cattle into southern ports. Whether accessing southern ports is restricted (by wet season access) could not be established but further investigations into market demand are warranted.
- The changing date of Ramadan offers an opportunity for northern cattle exporters. There is about 40,000 head per month spare capacity for the wet season (December–January–February) and the development of infrastructure that 'stores' cattle to ensure supply for the Indonesian market should be considered. Given cattle continued to be exported during the wet season, but only a small proportion move to southern ports, a reliable supply of cattle is

the constraint, and it is unlikely that year-round access roads will be built solely for the purpose of supplying cattle.

- A number of northern beef roads were shown to provide modest savings per head, ranging between $0.98/head and $5.39/head. The best of those, the Buntine Highway upgrade, has planned expenditure of $140 million and, depending on where those upgrades occurred, will provide savings of between $0.81/head and $2.72/head.
- Additionally, a number of pinch points were identified across the road network used by the live export industry. This identified some road segments where there is a potential constraint that hadn't been identified by stakeholders or in other studies. Additional assessments of the road condition and the potential constraints would be required to understand what the outcome would be for the live export industry. This would warrant further research.
- There are significant savings from moving live exports from the Inner Harbour at Fremantle Port to exporting from new port facilities at Kwinana at Cockburn Sound, with savings of $1.20/head for cattle and $0.40/head for sheep. These savings would be enhanced by minor improvements in the landside access roads, with an additional $0.50/head savings for all livestock moved using high performance vehicles from export depots to ports. The Westport review and planning for the expansion of Fremantle Port into the Outer Harbour including Cockburn Sound identified the need to develop new berthing facilities and landside infrastructure. The report acknowledges that urban and tourism development near the Inner Harbour has resulted in the southern side of the port becoming prime waterfront land for entertainment, recreational and residential use. As such, the odour impact of livestock shipments is affecting the amenity of residents and has further restricted development of the southern side of the port (Government of Western Australia, 2017). Future planning for the port expansion makes little reference to live export operations, and the movement of live export facilities doesn't currently form part of the justification for investments in expanding Cockburn Sound port infrastructure, even though the industry would benefit from significant time and cost savings if that happened.
- An upgrade to the road between Mount Gambier and Portland results in a small time reduction. More importantly, it results in many trips being under the driver fatigue thresholds, resulting in substantial cost savings.
- It is likely that there will be substantial savings in transport costs if cattle from the bluetongue zone are able to be exported from northern ports. We were not able to quantify what the savings might be in this project but would recommend ongoing development of a ground-up port and ship costing model to allow further analysis to be undertaken.
- The constraint across the northern wet season is the ability to source cattle on properties. The likely development of the onshore (unconventional) gas industry in the Beetaloo Basin in the Northern Territory could result in the building of roads that provide year-round access. If that is the case, the live export industry could work with companies that are developing gas fields to have roads constructed for mutual benefit. The recommendation of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory recommended that all levels of government, including the Australian Government, peak organisations, communities and gas companies, work to identify and manage infrastructure risks, including identifying and implementing options to fund any new infrastructure or upgrade existing

infrastructure. There will be opportunity to leverage off investments in economic infrastructure to support the gas industry to the benefit of the live export industry.

The challenge remains to prioritise investment. At this stage of the project we have identified a number of specific opportunities to improve livestock export supply chains domestically, which can be tested through TraNSIT and potentially other models. Stakeholders did make reference to previous reviews by Livecorp on port operations and costs, and these could be used as part of developing port costing models for future analysis. Separate to this project, CSIRO has begun discussing data access with port and ship operators and freight companies in order to generate reliable port costing models that can be applied to the problems highlighted.

Stakeholders recognised the complexity and increasing time and cost demands of the regulations that support live exports from Australia. They noted that the current regulatory environment is the most complex set of export regulations in the world, which creates a competitive disadvantage in trading. However, they also noted that the trade-off was clear, the industry needed to continue to deliver certainty of animal welfare outcomes to maintain a social license to operate, but that came at a higher cost. Future regulatory changes and reduction in regulatory burden is unlikely in the immediate future, and currently there are a number of reviews of the approvals process and standards that will be implemented. Once these are completed there is an opportunity to assess the 'workflow' of approvals processes, particularly Australian Maritime Safety Authority (AMSA), biosecurity clearance and loading where delays can cause significant demurrage costs and delays. It would be unwise to undertake this at present when there will inevitably be changes in policy and regulatory regimes.

There are obvious capacity constraints in receiving markets, with simple upgrades and interventions highlighted that would make significant time and cost savings for offloading of ships. In Indonesia, high transport and logistics costs and a lack of private sector infrastructure investment (meaning a greater reliance on public sector investments to overcome these issues) is a systemic issue, and it is unlikely that livestock importers alone will be able to make investments to a scale that would resolve system-wide problems. But the flow model did demonstrate that there are operational investments that can be made that will make a difference, such as ensuring there are adequate truck numbers for offloading, and therefore opportunities for supporting the trucking and logistics sector. The industry could work with trucking and logistics associations to build their members' capacity, and to move away from the current single operator model for trucking to collective or company-based model.

6 Conclusions/recommendations

The study highlighted some capacity constraints and bottlenecks, none of which are exclusive or unique to the industry. Physical infrastructure constraints, mostly on the road network, are unfortunately common across Australia and especially in industries characterised by geographic spread and fragmented supply. The small (economic) scale of the live export industry (1.5% of the value of Australian agricultural transport costs) makes it unlikely that it can 'lobby' for industry specific investments to overcome capacity constraints and bottlenecks. But the competitive advantage that the industry has in short shipping times and high quality assurance (through regulation) could be lost without continual enhancements and improvements to landside transport infrastructure across the cattle and sheep supply chains. Stakeholders emphasised the need to upgrade all weather roads, improve port operability (especially in tidal ports) and increase private sector investment in support infrastructure, such as registered premises. The need to continuously 'lobby' for road improvements was identified by the Australian Farm Institute (Keogh et. al.2016):

'There is an opportunity for livestock exporters to play a very prominent role in planning and advocacy associated with transport and logistics development in northern Australia, and such involvement would also confer stronger recognition of the economic significance of the sector amongst governments and livestock producers.'

6.1 Future research

The logistics for live export supply chain modelled in this project include all processes from farm gate to port gate. There are parts of the supply chain such as beyond the port gate, that currently are not included. Developing models capturing the processes and costs for those parts of the supply chain would allow for comparisons of the relative advantage in investing in improvements throughout. For example, development of the port handling costing model could then identify cost impacts. It was beyond the scope and resources of this project to develop and verify port handling costs with sufficient detail to allow such an analysis. Initial stakeholder engagement highlighted that it would require input from other industries, shipping companies and port operators to validate, however once developed, these stakeholders could be used to verify the model for the live export industry and the results and any implications provided to MLA and Livecorp. An immediate application will be in understanding the cost savings of opening northern ports for exports to China.

Movement to most ports will pass through urban roads, and the challenges of access to Fremantle Port along the urban road network were identified by stakeholders. TraNSIT has begun developing a 'cost' related to congestion for movement of agricultural freight in Indonesia and Vietnam but is yet to test that on Australian roads. An outcome of this project will be to add a congestion cost into the Australian model and test and validate that. It is likely that the 'cost' will be very low compared to the costs of congestion experienced at receiving ports.

Since the commencement of this project, the license for live export operations was questioned in light of the high mortality rate of a shipment to the Middle East in 2017. A closure of live export trade to some markets would lead to a major reduction in number of sheep exported from some ports (particularly Fremantle). Due to the lack of processing options in the vicinity of these supply chains, it would require long distance transport to existing processors. A next stage to this project would be to map out the transport costs under a reduced live export for some markets, along with option for new feedlot and processing options to reduce these impacts.

Within the project it also wasn't possible to visit all receiving ports. There are clearly operational efficiencies possible with reasonably low costs and simple invention, as demonstrated with the Port of Tanjung Priok flow model (Fig. 14). Further research into the efficiency of discharge could be undertaken at all major ports. This could consider the processed of discharge, and the movements from port to quarantine facilities and feedlots.

7 Key messages

- Supply chains are long and fragmented and the sourcing of animals is geographically spread. Changes to ownership and a lack of vertical integration also leads to inefficiencies within supply chains, captured in this study by the observation that inefficiencies and bottlenecks are often ‘caused somewhere else by someone else’.
- While there are many constraints identified, many are commercial considerations that can be overcome through private sector investment where a business case supports investment.
- The small scale of the industry will make it difficult to justify public investment in dedicated infrastructure or regulatory reforms.
- The industry could focus on ensuring ongoing access to high performance vehicles to ports, as these efficiencies provide the greatest time and cost savings.
- For the northern cattle industry there are likely market opportunity derived from overcoming property level cattle supply constraints with the changing date of Ramadan. The likely development of the onshore gas industry could provide a mechanism for developing year-round access to holding infrastructure that could ensure year-round consistent cattle supply.
- There are likely significant savings in time and costs that can be made by improving port operations and understanding costs. There are also savings that could be made by gaining a better understanding of receiving markets, where processes and flow will reveal opportunities to improve the transport of livestock in receiving ports. These savings would reduce costs and provide animal welfare benefits.

8 Bibliography

ACIL Allen Consulting (2016) Northern Beef Infrastructure Audit: Infrastructure Plan and Business case summaries: Milestone 4 Final report to Meat and Livestock Australia.

ATA (2016). Truck Impact Chart. Australian Trucking Association. Edition 2.1, www.truck.net.au.

CSIRO (2016) Transport Network Strategic Investment Tool (TraNSIT) – Application to Northern Australia Beef Roads Submissions. CSIRO, Australia.

DEE (2016). National Greenhouse Accounts Factors. Australian Government – Department of the Environment and Energy. www.environment.gov.au.

Government of Western Australia (2017) Westport: Preparing for the strategy, www.transport.wa.gov.au/projects/westport-port-and-environs-strategy.asp. Higgins AJ, McFallan S, McKeown A, Bruce C, Marinoni O, Chilcott C, Stone P, Laredo L, and Beaty M (2017). TraNSIT: Unlocking options for efficient logistics infrastructure in Australian agriculture. Final Report. CSIRO, Australia. Available at: www.csiro.au/TraNSIT.

Higgins A, McFallan S, Laredo L, Prestwidge D, Stone P (2015) TRANSIT – A model for simulating infrastructure and policy interventions in agriculture logistics: Application to the northern Australia beef industry. *Computers and Electronics and Agriculture* 114, 32–42.

Higgins A, Watson I, Chilcott C, Zhou, M, Garcia-Flores, R, Eady, S, McFallan, S, Prestwidge, D, and Laredo, L (2013). Optimising capital investment and operations for the livestock industry in Northern Australia. *The Rangeland Journal* 35, 181–191. doi:10.1071/RJ12090.

Keogh M, Henry M, Day N (2016) Enhancing the competitiveness of the Australian livestock export industry. Research report by the Australian Farm Institute. Surry Hills. Australia.

9 Appendix

9.1 Overview of TraNSIT

TraNSIT is a modularised tool (Fig. 15) where data for each agricultural sector is an input to the core engine, along with the infrastructure or regulatory scenarios being tested. TraNSIT is programmed in Python (www.python.org) and uses ESRI ArcGIS network analyst capability while accommodating multiple features about the road network and individual segments. Road network data are critical and roads ranked as primary, secondary and minor (including unsealed) roads are included. The road layer, represented in Fig. 16, was constructed using shape files defining location, ranking, access restrictions and other road information (breakdown pads, biosecurity restrictions, rest stops) from several sources. Road layer characteristics were supplied by Geoscience Australia, each state government's roads department, various regional councils and the National Heavy Vehicle Regulator (NHVR). The NHVR provided information on access limitations for different types of heavy vehicles across the road network. The roads were classed as primary, secondary and minor (Fig. 16), with these roads further broken into segments with attributes containing surface type, width, speed limit and any special limits (e.g. one-way bridges). These data were collected from the transport departments of each state/territory in mainland Australia. All of these attributes affect average speed and transport cost per kilometre (Fig. 17). The road layer required enhancements (e.g. creating connections, correcting locations of some roads) to provide a fully routable road layer.

The road network has been updated (particularly for southern Australia) to accommodate minor roads linking farms to storage facilities and processors. The layer also contains additional features including average speeds (by vehicle type), road conditions (sealed, narrow sealed, unsealed), and other features (decoupling locations, bridge limits, tick lines) that affect travel costs and vehicle routes.

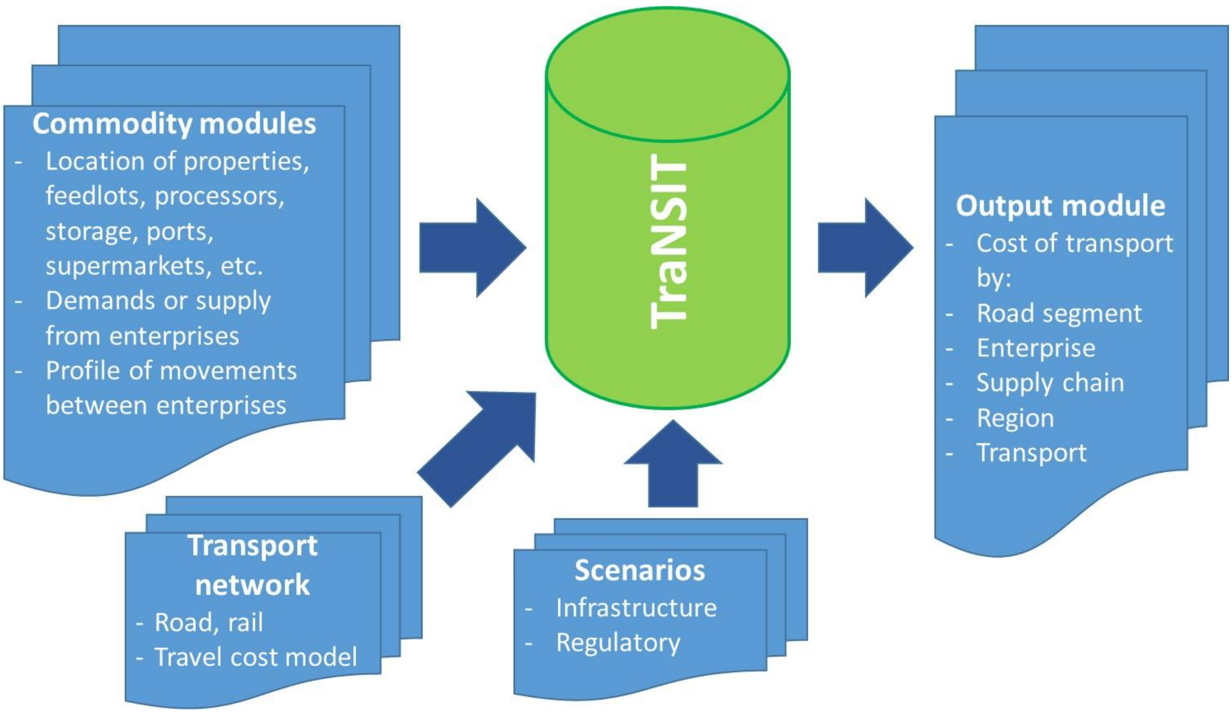

Fig. 15 Components of TraNSIT.

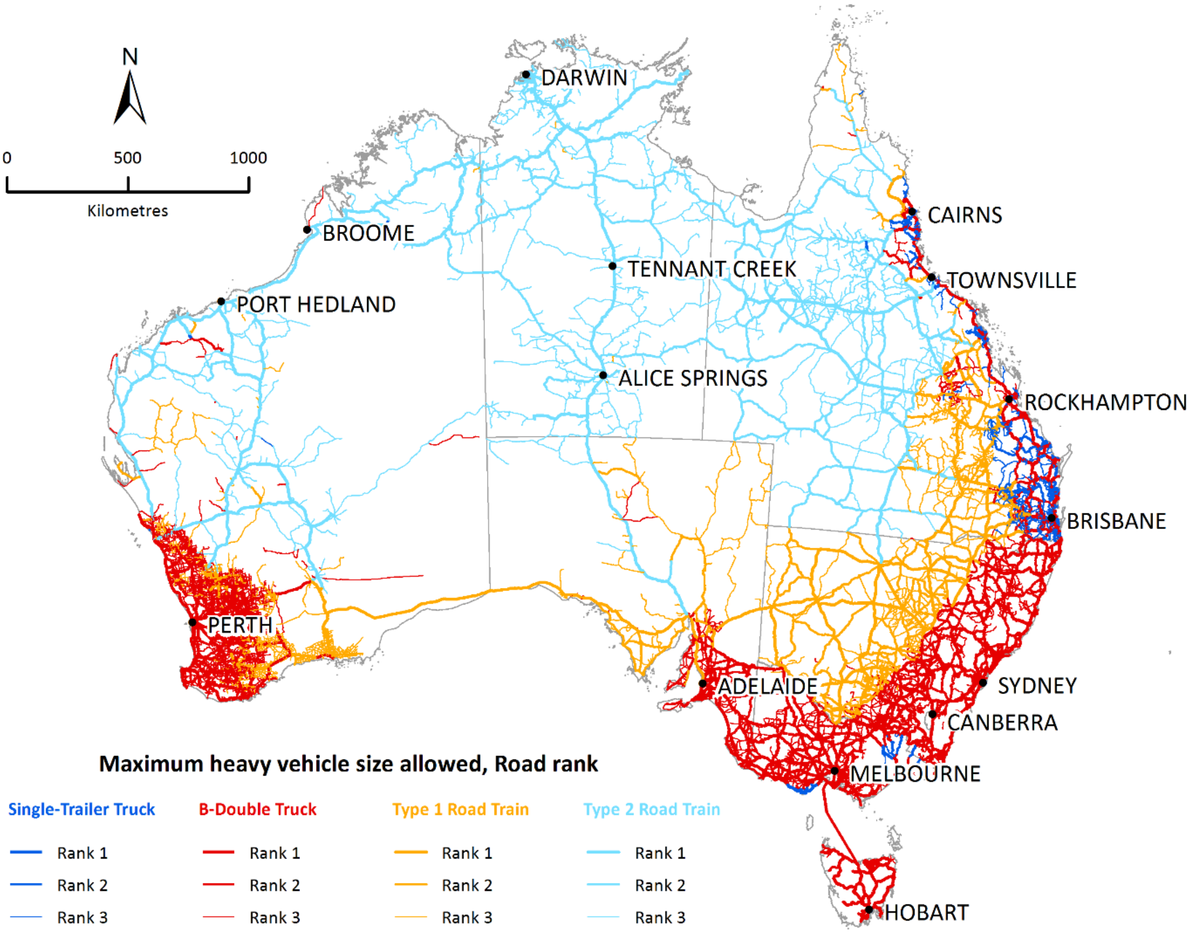

Fig. 16 Current road layer used in TraNSIT showing road rankings and heavy vehicle access. A denser (Rank 3) road layer has been added at some locations, when required, for some case studies.

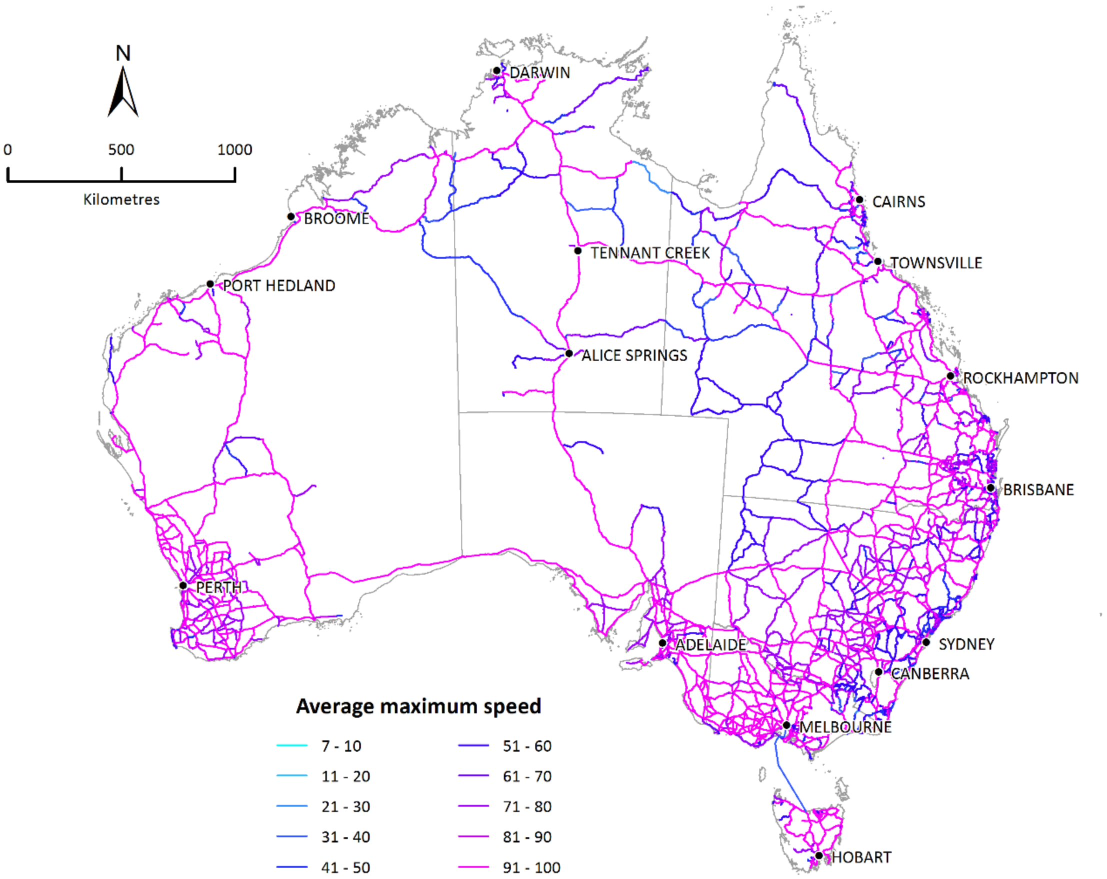

Fig. 17 Average maximum speed across the road network used in TraNSIT (minor Rank 3 roads not shown).

TraNSIT uses a ground up costing model for both road and rail. For road, it is based on the Freight Metrics (www.freightmetrics.com.au) tool, and additional vehicle types (e.g. refrigerated, heavy rigid) have being incorporated within TraNSIT to accommodate vehicles used for different types of agriculture and post-processing supply chains. A snapshot of the transport costs for different speeds and vehicles is contained in Table 11. The costing model has been enhanced for different types of unsealed roads, accommodating additional maintenance costs for vehicles. Loading and unloading time and costs are enterprise specific and are included in the freight travel time and costs as are vehicle decoupling time and costs. Both of these trip elements are added at the time of action. This process allows these costs to be included in the analysis to identify the best freight combination for the specific freight task. Further to this, driver fatigue management time and costs are added. Although as this activity can be managed as needed by a driver it is added post route solution but prior to the selection of the best combination. This process can result in the selection of a smaller combination than may be expected. For example, where the specific task begins in a type 2 access area and ends at a B-double access area, the B-double may be selected in preference to a higher capacity combination to complete a freight task as the route taken may be more direct due to access rights and the lack of decoupling may save the time required to eliminate some of the fatigue management costs. Greenhouse gas emissions are also calculated using information on heavy vehicle fuel usage published by the Australian Trucking Association (ATA, 2016) and emissions factors for different fuel combustion published in the National Greenhouse Accounts Factors (DEE, 2016).

Table 11 Overview of vehicle transport costs.

PBS Scheme	Modelled cost ($/km) per travel speed			Additional maintenance costs		
	100 km/h	60 km/h	20 km/h	Good Unsealed	Poor Unsealed	Idle cost ($/h)
Level 1 (Semitrailer)	1.91	2.58	6.11	0.09	0.26	119
Level 2A (B-double)	2.35	3.13	7.36	0.13	0.39	141
Level 3A (Type 1)	2.71	3.54	6.81	0.16	0.49	169
Level 4A (Type 2)	3.43	4.36	8.22	0.24	0.72	177

Table 12 List of vehicle combinations that can be selected, depending on road access at origin.

TraNSIT cost model	Road access class – PBS level			
	4A	3A	2A	1
Mod 1	4A	3A	1	1
Mod 2	4A	2A	2A	1
Mod 3	3A	3A	1	1
Mod 4	2A	2A	2A	1
Mod 5	1	1	1	1
Cap tonnes[A]	84	56	42	28
Length (m)	53.5	36.5	26	19

[A] Depends on bulk density and axel load limits

TraNSIT simulates the number of vehicle trips per month moved between origin and destination enterprises. The goal of the TraNSIT module is to optimise the transport route and vehicle selection along the road/rail network for each of these trips from origin to destination, and then calculate the cumulative impacts at the enterprise or regional scale while evaluating against constraints on the number of vehicle trips on each route. To determine the optimal route, the analysis takes into account parameters such as costs, vehicle access, vehicle types and hierarchical value of the road segments. The least cost vehicle combination selected depends on heavy vehicle access restrictions throughout the journey from origin to destination. These restrictions define where road trains can decouple and influence the cost of operating larger versus smaller vehicle combinations for each part of the journey. For example, if the first 50 km of the journey is PBS Level 4A vehicle access, and the last 800 km is B-double vehicle access, the least cost option would be to use a PBS Level 2A for the entire journey, due to the high cost of decoupling after 50 km.

Table 12 shows the list of models for vehicle selection for a trip between an origin and destination. TraNSIT will select the least cost model depending on the vehicle access limitations between origin and destination and volume transported. Models 1 to 2 apply to trips that allow a PBS Level 4A road train for at least part of the journey but will accept smaller vehicles. Model 1 is typical for triple road trains that would normally decouple into PBS Level 3A double road trains or semitrailers for roads that are limited to smaller vehicles. Other vehicle types (e.g. BAB Quads, AB-triples, A-doubles) can readily be added. Model 3 is for trips where the maximum vehicle is a PBS Level 3A for any part of the journey. The vehicle selected may also affect the optimal route taken. For example, the use of a semitrailer vehicle from the origin could take the shortest travel time path and would not need to decouple. Commencing travel from the origin in a PBS Level 3A or 4A vehicle may take a longer travel time path to increase the proportion of the trip in the higher performance vehicle before decoupling into smaller vehicles, to minimise costs. It is essential for all of these parameters to link together logically, to allow proper solving of optimal routes.

Since a property is not always geographically attached to a road in the road network, a trip from an origin to destination (O–D) is modelled to travel from the closest road segment to the origin, and finish at the closest point on a road segment to the destination point. This process is repeated for all routes, always searching for the minimum cost route (including penalty costs) and selecting it as the optimal route.

Fig. 18 represents a process diagram of TraNSIT. The first processing stage of TraNSIT is to construct a set of vehicle and train trips between enterprises across the supply chains. Once the set of movements have been produced, TraNSIT finds the optimal route (based on transport cost) and selection of vehicle types, for each Origin–Destination (O–D) pair input. Optimal road sections travelled for each O–D pair are saved. These road sections can be constrained by access restrictions such as vehicle size/load limit, which will determine the route final set of route segments. The optimal route selected may not necessarily be the actual route taken by the driver in the existing network but rather the route that would be taken should the driver be seeking a least travel cost option. Once the optimal set of segments for all O–D pairs are saved, Python scripts calculate the cost of transport and number of vehicles for a given resource flow between each O–D pair. These are then aggregated over all O–D pairs to provide a total cost of transport for the scenario. It currently takes about 10 hours (on a 25 core – Dual Xeon CPU 3.3 GhZ processor) to run all of steps of TraNSIT shown in Fig. 18 for the 182,000 different O–Ds across all plantation forestry.

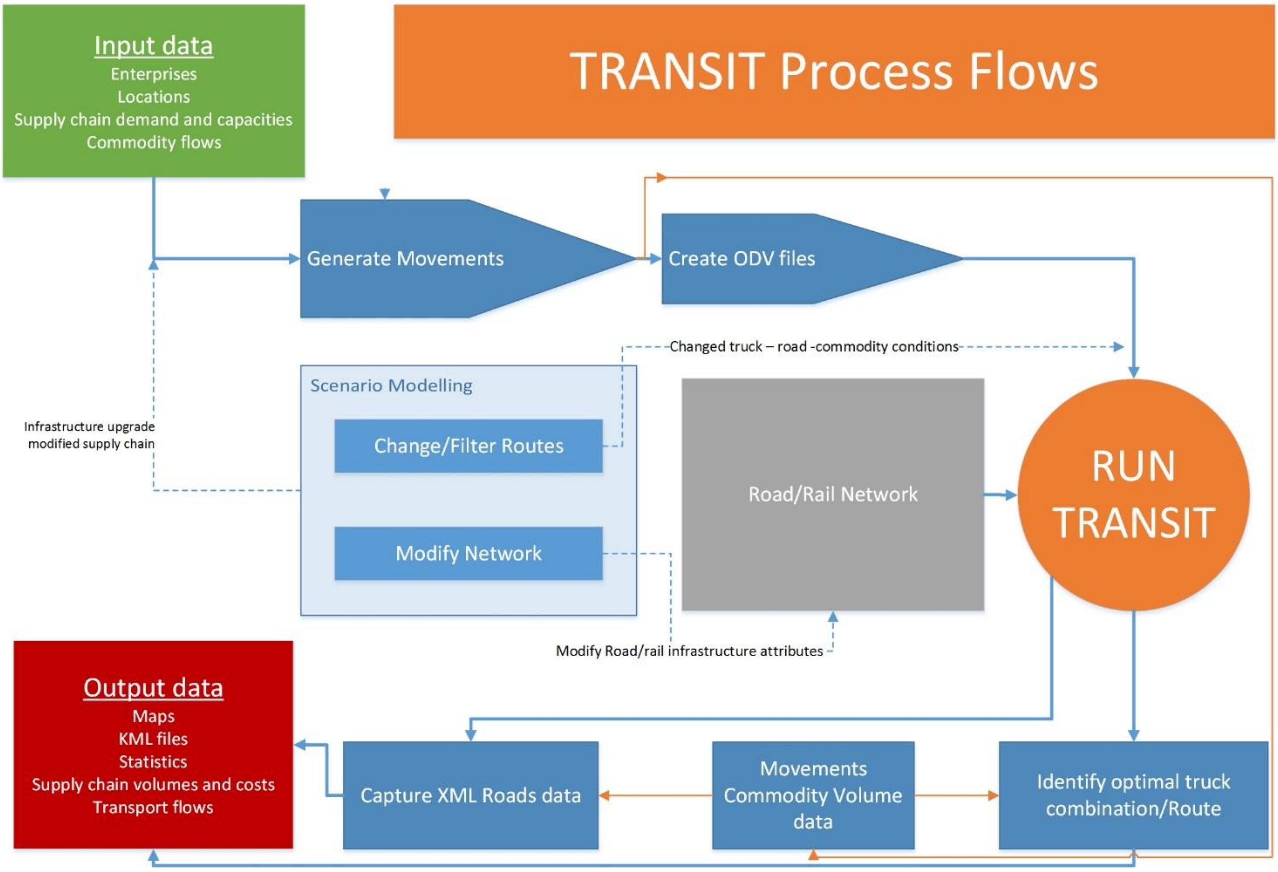

Fig. 18 Process diagram of TraNSIT, comprising the stages from set up to running of each model component.

9.2 NT Government Port data.

Pastoral Market Update – NT Department of Primary Industry and Resources

Live Cattle and Buffalo Exports through the Port of Darwin January 1996 to September 2017

Total cattle	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	YTD Sept 2017
Brunei	4,041	5,650	6,948	14,862	16,062	16,155	19,085	16,572	14,101	6,642	7,453	4,916	4,288	3,131	2,853	4,163	4,639	4,043	4,925	4,122	3,379	1,893
Cambodia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,766	-
Egypt	-	-	34,286	28,350	21,419	52,692	10,873	-	-	-	-	-	-	-	-	5,363	-	-	-	-	-	-
Indonesia	232,207	244,701	19,614	65,277	136,323	151,190	199,327	182,624	158,600	186,031	190,297	258,736	341,768	330,433	273,396	239,346	201,748	282,022	386,183	341,759	296,230	180,262
Jordan	-	-	-	-	-	-	688	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Libya	-	9,518	15,163	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Philippines	124,284	167,186	133,265	152,198	108,957	31,984	65,931	51,792	31,623	13,052	10,071	12,041	12,247	10,422	12,784	16,068	27,324	22,403	16,080	23,611	4,697	-
Sabah	4,465	3,278	541	-	-	110	318	224	304	1,905	5,758	1,397	2,985	1,410	982	-	460	-	-	-	-	1,500
Saudi Arabia	-	-	-	-	-	-	6,550	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarawak	-	479	-	1,028	-	-	1,033	320	-	4,893	1,883	2,143	2,340	-	1,615	1,197	-	800	-	-	1,220	340
Thailand	820	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,154	-	-
Timor Leste	-	-	-	-	-	-	32	58	35	-	-	-	-	-	-	-	-	-	-	-	-	800
Vietnam	-	-	-	-	-	941	-	-	-	-	-	-	-	-	-	945	2,801	35,396	64,461	100,119	36,405	29,021
W-Malaysia	17,718	17,384	9,622	18,296	16,418	5,055	18,765	9,028	6,379	93	12,412	3,813	1,296	1,918	3,975	2,535	10,018	14,952	22,309	11,803	10,959	10,641
Totals	**383,535**	**448,196**	**219,439**	**280,011**	**299,179**	**258,127**	**322,602**	**260,618**	**211,042**	**212,616**	**227,874**	**283,046**	**364,924**	**347,314**	**295,605**	**269,617**	**246,990**	**359,616**	**493,958**	**487,568**	**355,656**	**224,457**

Source: DPIR, Pastoral Market Update – January 1996 to September 2017

NT buffalo	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	YTD Sept 2017
Brunei	605	514	804	1,135	2,326	2,683	3,129	2,774	2,279	816	492	306	306	327	312	470	628	400	488	625	599	148
Egypt																1,371	-	-	-	-	-	-
Indonesia										100	820	2,865	3,815	3,274	2,126		-	201	-	4	-	694
Jordan																	-	-	-	-	-	-
Philippines																	-	199	-	-	-	-
Sabah			99							314	659	152	236	176	103		-	-	-	-	-	-
Saudi Arabia																	-	-	-	-	-	-
Sarawak			287			40	57										-	-	-	-	-	-
Thailand																	-	-	-	-	-	-
Timor Leste						4											-	-	-	-	-	-
Vietnam																	-	-	4,577	4,468	3,981	2,969
W-Malaysia				1,225	337		173	32	1,556	672	5,777	582	280				-	-	-	-	1,212	3,971
Totals	**605**	**514**	**1,190**	**2,360**	**2,663**	**2,727**	**3,359**	**2,806**	**3,835**	**1,902**	**7,748**	**3,905**	**4,637**	**3,777**	**2,541**	**1,841**	**628**	**800**	**5,065**	**5,097**	**5,792**	**7,782**

Source: DPIR, Pastoral Market Update – January 1996 to September 2017

9.3 Townsville Port Data

Year	No. of Head	No. of Shipments
1986/87	11,044	13
1987/88	774	1
1988/89	8,592	10
1989/90	6,306	5
1990/91	9,628	8
1991/92	16,986	10
1992/93	2,870	2
1993/94	4,128	6
1994/95	5,806	4
1995/96	59,264	45
1996/97	60,054	43
1997/98	46,115	31
1998/99	28,416	18
1999/00	122,338	38
2000/01	81,512	23
2001/02	77,458	30
2002/03	165,181	52
2003/04	16,807	6
2004/05	2,187	2
2005/06	12,755	2
2006/07	37,682	2
2007/08	27,159	2
2008/09	131,887	11
2009/10	90,062	7
2010/11	47,776	10
2011/12	21,725	4
2012/13	4,144	1
2013/14	201,810	31
2014/15	305,779	49
2015/16	261,552	60
2016/17	189,409	50
2017/18 YTD	52,783	12

	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
VIETNAM	0	0	0	0	0	0	63,339	125,117	113,152	65,865	17,417
PHILIPPINES	0	0	0	0	0	0	7,235	0	2,625	4,176	0
MALAYSIA	0	0	0	0	0	0	2,714	3,465	0	0	0
INDONESIA	27,159	131,887	72,876	33,609	21,725	4,144	128,522	177,197	145,775	119,368	35,366
EGYPT	0	0	17,186	14,167	0	0	0	0	0	0	0