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Final report

Small research and development activity

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1 Acronyms

ACRONYM	DEFINITION
ADB	Asian Development Bank
AECOM	(multinational engineering firm)
ALFI	Indonesian Logistics and Forwarders Association
BOT	Build-Operate-Transfer
BPS	Statistics Indonesia
BULOG	Indonesia Logistics Bureau
ASEAN	The Association of Southeast Asian Nations
CASRAD	(Vietnamese) Centre for Agrarian Systems Research and Development
CIRAD	French Agricultural Research Centre for International Development
CIAT	International Centre for Tropical Agriculture
DARD	(Vietnamese) Department of Agriculture and Rural Development
ESRI	Environmental Systems Research Institute
FGG	FocusGroupGo
FPJMN	(Indonesian) Medium-Term National Development Plan
GAPMMI	Indonesian Food & Beverage Association
GDP	Gross Domestic Product
GIS	Geographic Information System
GSO	(Vietnamese) General Statistics Office
HERE	(company that provides mapping and location data and related services)
ICARD	Indonesian Centre for Animal Research and Development
ICASEPS	Indonesian Centre for Agricultural Socio Economic and Policy Studies
IDR	Indonesian Rupiah
IPSARD	(Vietnamese) Institute of Policy and Strategy for Agriculture and Rural Development
JICA	Japan International Cooperation Agency
KADIN	Indonesia Chamber of Commerce and Industry
LMI	Lower Mekong Initiative
MARD (-CIS)	(Vietnamese) Ministry of Agriculture and Rural Development (Centre for Informatics and Statistics)
MC	Moc Chau (District, Vietnam)
MS	Mai Son (District, Vietnam)
NIAPP	(Vietnamese) National Institute of Agricultural Planning and Projection
NOMAFSI	Northern Mountainous Agriculture and Forestry Science Institute
PELNI	Indonesian National Shipping
QGIS	(open source GIS software)
Rp	(Indonesian) rupiah
SRA	Small Research Activity
TDSI	(Vietnamese) Transport and Development Strategy Institute

ACRONYM	DEFINITION
TEU	Twenty-foot equivalent unit
TraNSIT	Transport Network Strategic Investment Tool
VAST	Vietnam Academy of Science and Technology
VND	Vietnamese Dong

2 Acknowledgments

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In Vietnam we would like also to thanks the government officials and private sector representatives in Son La province and the districts of Mai Son and Moc Chau officials for their inputs and participation into the work.

3 Executive summary

Getting products to market where transport infrastructure is underdeveloped or unreliable is a major barrier to agricultural development, particularly in less developed countries. The rapid increasing demand for higher-value food products throughout Asia may not necessarily translate to opportunities for small-scale producers if they are unable to get their products to market in a timely and cost-efficient manner. Enhancing connectivity is critical for countries and communities to efficiently access domestic and global markets, to enhance spatial inclusion of remote and rural communities and build resilience in the transport and logistics systems (World Bank 2019).

CSIRO developed the Transport Network Strategic Investment Tool (TraNSIT) to provide an evidence-based approach for identifying both infrastructure investment that improves transport efficiency and policy changes that reduce transport costs to Australian farmers.

In this project, the TraNSIT model and other spatial analytics approaches were successfully adapted with a proof-of-concept model developed and applied to a range of real-life scenarios in both Indonesia and Vietnam, including the quantification of transport costs through the supply chain and identification of transport inefficiencies and at-risk of failure infrastructure. The project also confirmed there is a critical need for more analytical and evidence-based decision making and policy relating to transport infrastructure plans and investment options in Vietnam and Indonesia.

This project demonstrated how spatial data analytics and optimisation modelling can be applied to complex, real-life transport investment and planning scenarios at different administrative, investment and operating scales. It also was applied across different agricultural value chains. These applications can directly support public and private sector institutions and planners to better analyse problems, evaluate options and allocate resources in ways that reduce transport and logistics costs, and improve connectivity for agricultural value chains, smallholder farmers and rural communities.

The scenario modelling provided insights into about transport system changes and how impacts are distributed to different supply chain actors, in terms of benefits and adverse or perverse outcomes. The disproportionate proportion of burden for the logistics and transport that fall on the production sector was also able to be quantified. A set of technical conclusions and recommendations for how TraNSIT and other spatial analytics approaches could be better adapted and integrated in Indonesia and Vietnam have been proposed. These include:

- Expand the analytical focus of the “TraNSIT model” to include broader spatial analytics and big data applications.
- Adapt and apply spatial analytics and big-data approaches (including TraNSIT) to examine a range of priority transport connectivity issues (thematic and sectoral).
- Improve availability and usability of existing statistical and spatial data sets.
- Improve and refine TraNSIT model functionality and accuracy.
- Apply TraNSIT and spatial analytics to support decision-making for improving rural road infrastructure and connectivity that reduces rural poverty.
- Support ongoing collaboration in big-data analytics such as the Commercial Vehicle Tracking System (CVTS) data in Vietnam.

Whilst technically feasible there are major institutional complexities, capability gaps and resourcing challenges that complicate adoption and integration and TraNSIT and broader spatial analytic approaches. These barriers must be addressed in order for these tools and approaches to be realistically integrated into an operational analytical and institutional system capable of translating outputs to impacts. Detailed recommendations and solution options have been proposed to address institutional capability gaps, hardware and software gaps and resourcing, and cross-institutional collaboration challenges. The evaluation of innovation models and platforms that promote multi-stakeholder and multi-institutional collaboration in a digital data and spatial analytics hub or cooperative research centre, with a focus on transportation and connectivity could be one important next step.

4 Background

Demand for beef and higher-value food products throughout Southeast Asia and China has driven increased trade in cattle and horticulture, with Australia a beneficiary in providing high-value products into the food services sector. The transformation of agrifood systems in Asia has been documented by Reardon and Timmers (2014) with five transformations emerging: (1) urbanisation; (2) diet change; (3) agrifood system transformation; (4) rural factor market (i.e. land, variable input, and credit markets) transformation; and (5) intensification of farm technology. The transformation is not linear, rather piecemeal, complicated, and sometimes rapid. In Southeast Asia, the urban food demand from China and Indonesia and the construction of large transport infrastructure have created a large market pull, causing disruptions to traditional agricultural and food supply chains.

In Indonesia, the National Medium-Term Development Plan 2015-2019 (Coordinating Ministry for Economic Affairs, 2011) and the Maritime Highway (*toll laut*) strategy with the goal of strengthen maritime infrastructure and shipping lines to improve connectivity through improved infrastructure, through targeted port investments and interconnection of feeder ports to reduce logistics costs. The plans also recognise the need to develop and improve hinterland connections via road and rail links to industrial centres, cities and transport hubs. There were also supporting plans to increase agricultural production through intensification particularly in staples such as rice, maize and soybean. More recent plans such as the 2020- 2024 National Medium-Term Development Plan (RPJMN) continue to re-enforce the importance of connectivity which is one of the crucial themes for infrastructure development, with $450B (USD) of investment allocated to underpin the development, although recent analysis suggest those spending targets wont be reached due to COVID-19 impacts and the emphasis shift towards economic recovery (ADB 2020).

The new draft of the Vietnam Government's vision for growth in the Socioeconomic Development Strategy (SEDS) 2021 – 2030[1] has a focus on rapid and sustainable development based mainly on science and technology, innovation, and digital transformation. One of the strategy's ten tasks and directions is "*Development of regional infrastructure, economy, marine economy, taking urban areas as the driving force for regional development and promoting the construction of new rural areas"*. There will be a focus on investing in key national infrastructure projects, especially in transport, energy and digital infrastructure to fundamentally overcome bottlenecks for development, and strengthen connectivity with the region and the world. Improving the infrastructrue connectivity of regional and rural value chains to urban and international markets is also a priority. In input to the SEDS, the World Bank (2020) identified '*growing uncertainty in global trade and new technologies [as] two of the most important mega-trends that can impact the Vietnamese economy.'*

The increased and changing demand for food will have profound effects on regional food supply chains. Whereas previous research and development efforts and investments by governments and donors focused on improving productivity for small-scale producers to ensure adequate food supply, there has been far less effort to understand both the challenges of getting food to market and the implications of changing market dynamics on post-farm gate segments of the supply chain. The issue of access to good quality supply chain infrastructure is now a regular feature of the political discourse, national government policy and investment from large donors such as:

- The World Bank has recognised the need to invest in road and port infrastructure to improve connectivity to supply domestic markets and increase access to fresh produce throughout Indonesia (The World Bank Group, 2015) as well as supporting the transformation of agricultural supply chains to improve market access through improved competitiveness in Vietnam (The World Bank Group, 2017). As well as increased investment, they have recently advocated for "...*improved efficiency in infrastructure spending, which is to get more bang for the buck*…" (World Bank, 2020).
- In Vietnam, the World Bank's flagship Vietnam Development Report (VDR) 2019: Connecting Vietnam for Growth and Shared Prosperity (World Bank 2019) provides a

[1] *Phần thứ hai: Chiến lược phát triển Kinh tế - xã hội 2021 – 2030 | Báo Công an nhân dân điện tử (cand.com.vn)*

comprehensive overview of connectivity issues in Vietnam and some strategic recommendations. It uses a set of new analytical tools and analyses to inform policy makers and other key stakeholders on policy options and investment strategies to support Vietnam's integration with global and domestic markets, strengthen, and promote spatial inclusion, along with its resilience. It provides recommendations in four mutally reinforcing areas of connectivity: (a) Integration with Global Markets, (b) Integration across Domestic Markets, (c) Spatial Inclusion, and (d) Building Resilience.

- The Asian Development Bank allocated nearly two thirds of its budget for 2016-2018 to infrastructure development to create and expand economic activity and access to markets in 'lagging' areas (defined as those behind in socio-economic status and with specific reference to rural areas and supporting agricultural development). The ADB's long term strategy is to support agriculture and rural development mainly through infrastructure for rural transport, irrigation and water systems, and microfinance. This strategy was reiterated in the 2020 Country Partnership Strategy report 2020. (ADB, 2008, 2014 & 2020).
- The Japan International Cooperation Agency has supported the development of economic and social infrastructure through loan facilities to upgrade bridges throughout the Vietnamese road networks (JICA, 2015).
- The Master Plan on ASEAN Connectivity 2025 (ASEAN, 2016) recognises the need to increase investments in sustainable infrastructure that connect people to markets to deliver economic growth and improve the quality of life across the ASEAN states. This includes improving logistics and coordination across member states by identifying bottlenecks in supply chains and tackling critical policy issues. Critical trends identified which are relevant to this study include:
    - The rise of the consumer class (households with incomes where they can make significant discretionary spending) with the prediction this will double to 163 million households by 2030.
    - The need to improve productivity to maintain economic growth within the region, and to allow products from ASEAN States to reach new and emerging markets.
    - Recent change in the flow of goods, with a greater proportion of consumption and demand to come from China, India and Japan, as opposed to Western markets. This is driven by the growth in those economies as well as liberalisation through regional trade deals such as the Trans-Pacific Partnership.

Transport represents a high proportion of farm gate costs of moving livestock and crops to processors and local markets throughout the region. Some estimates put this cost at greater than 40% of the total farm gate cost (Agrifutures Australia, 2019; Higgins et al., 2018; Goucher, 2011), and as such could impede investment in agriculture and rural development. This is compounded by poor transport network infrastructure (roads, ports) throughout the supply chain (storage/processing/marketing), wet weather accessibility constraints, poor utilisation of cattle ships, food losses in transit, congestion, and an inconsistent regulatory and policy regime which limits cross-border movements. In Indonesia, logistics costs are on average 14.08% of total production costs across commodities (Sinaga, 2011). Data from the Industry Ministry showed Indonesia's logistics costs to be 23.6% of the country's GDP in 2014, compared to 9.9% in the United States (Jakarta Post, 2014). The Indonesian Logistics and Forwarders Association (ALFI) estimated logistics costs as greater than 25% of GDP until 2015 and then forecast a reduction to 21% by 2019 (pers comm). In Vietnam logistics costs were estimated to be approximately 25% of GDP (Blancas et al., 2014) with the Vietnam Logistics Business Association estimated transport accounted for more than 50% of those costs (pers comm.).

Critically, as the scale of on-farm production reduces (as smallholders begin supplying new markets) the network of supply becomes more fragmented. In this case, the ability to meet market requirements becomes even more dependent on unreliable transport infrastructure and consolidation and distribution networks. This can increase transport cost to small-scale farmers, but also decrease the quality of the product (e.g. through shrinkage or damage) passing through the supply chain. Similarly, if transport costs remain high, the 'economic' catchment where traders and buyers are able to purchase is reduced, thus reducing market options for geographically isolated farmers.

The apparent transformation in agrifood systems throughout Asia, driven by increased demand from growing urban populations in China, Indonesia and Vietnam raises several critical issues for consideration for government policy makers:

- As supply chains become longer and geographically spread, they become more prone to disruption through extreme and unpredictable climatic events that can cause significant and major disruptions. These disruptions can cause direct impacts by cutting transport routes, energy and fresh water supplies and causing physical damage to plant and equipment. Governments will need to consider how to mitigate against these shocks to supply chains through strategies such as building greater and distributed storage; aggregating packing, grading hubs and distribution centres; and cold chain storage. There is also a need to have sufficient redundancies in supply chain facilities and transport and logistical infrastructure to accommodate growth.
- It is well known that improved infrastructure and regulatory changes will reduce costs to producers and improve market access. However, a comprehensive and independent analysis of the options is required to identify where investments would have the greatest benefits and provide a strong case for support and investment from the relevant agencies (transport ministries, investment banks, donors).

In Australian agriculture, the project team has developed and deployed modelling and analysis of agricultural supply chain movements across a range of commodities and explored how changes/improvements increase efficiency and reduce costs in those commodities. TraNSIT (Higgins et al., 2015) was developed to map the complex agriculture movements in Australia, from individual properties through the supply chain to market. It has been extensively validated and adopted to reduce costs to industry, to support investment decisions and to optimise supply chains to improve market access to domestic and export markets.

The aim of this project - *Enhancing smallholder linkages to markets by optimising transport and logistics infrastructure* - was to further develop and adapt those approaches in Indonesia and Vietnam, and evaluate opportunities to reduce logistics costs to small-scale farmers, and contribute to more informed policy on infrastructure that promotes development and access to markets.

This report provides a summary of the results of the project.

5 Project Objectives

The Project Objectives were to:

1. Further develop the adapted TraNSIT models for scenarios in Indonesia and Vietnam to provide a proof-of-concept for stakeholders and develop prototype models (TraNSIT.id and TraNSIT.vn);
2. Develop an understanding of the links between infrastructure, relationships and institutional aspects of transport bottlenecks, and understand critical stakeholders and collaborators who will translate outputs into impact;
3. Understand the capital, skills and equipment requirements to establish TraNSIT.id and TraNSIT.vn within country;
4. Develop a business case and proposal for a larger project: “Linking smallholder farmers to markets: through improved transport infrastructure, logistics and investments in Indonesia and Vietnam“.

Importantly, the intention of this phase of work was to develop an understanding of how the findings from the scenarios would translate to impact with decision makers, the private sector and farmers (or other potential beneficiaries and donors). In doing that, we continued to establish institutional arrangements and integration with these stakeholders.

6 Methodology

The project applied a combination of methods and approaches. These included key informant interviews and direct observations in the field, stakeholder consultations, secondary data compilation and analysis, statistical and GIS analyses, and optimisation modelling. The approach and focus of application was adapted to suit the needs and interests of stakeholders in each country, and as such there are the analysis per county different in the level of detail provided.

In Indonesia, the research focused on commodities, with efforts directed towards stakeholder engagement within commodity sectors and with government agencies supporting these sectors. Given the Indonesian archipelagos unique geographic challenges and the Indonesian Government's aspiration to have price parity for food staples across the country, the goal was to demonstrate national-scale transport and logistics solutions. To achieve this, we applied the TraNSIT to model the transport of rice. Data were collected for beef and sugar to help identify data collection processes across the different commodity space. This approach was guided by the Indonesian government's policies for domestic agricultural production and food security as well as the National Logistics Blueprint which together aim to ensure equitable distribution of strategic commodities throughout Indonesia at affordable prices. The policy includes a goal to understand economic corridors and connectivity across the supply chains, reduce logistics costs and flow of goods and to support the policy delivery through inclusion of IT platforms. In terms of commodities to focus on for the study, staple foods such as rice, maize, soybeans, beef and sugar were initially considered, however due to data and stakeholders access and availability, the analysis was limited to rice, beef and sugar.

In Vietnam, research was focussed on Son La Province in the north-western mountainous region. The approach was to apply and evaluate TraNSIT in a set of scenarios at different administrative scales: provincial, district and commune-level. The rationale for choosing Son La was:

- It is an important agricultural province for maize, cassava, sugarcane and higher-value products such as fruit, vegetables, coffee, tea, and dairy;
- The relatively remote and mountainous topography, and limited road infrastructure create challenges for connecting agricultural products and rural populations to markets and services;
- The province has higher rates of poverty and ethnic group populations which are often disadvantaged by poor access to roads, services, and markets;
- There is considerable existing knowledge, data, and experience about key agricultural supply chains from past and ongoing research in Son La, much of it supported by ACIAR;
- There are well-established relationships with provincial and district Governments and local farmers and industry contacts.

International and domestic travel restrictions caused by the global COVID-19 outbreak resulted in some disruptions and delays to project activities. However, the project was able to adapt and proceed effectively with remote collaboration between Australian and Vietnamese research partners.

Objective 1. Further develop the adapted TraNSIT models for scenarios in Indonesia and Vietnam

TraNSIT uses assumptions about production, processing and supply to predict transport/product movements and freight costs across the country. As such it requires data on production (tonnes/ha, locations, etc), road/rail/shipping networks, vehicle loads, processing/storage facilities (including capacity) and markets. This draws on both secondary data and expert information from production/logistics companies. Once baseline scenarios are established, the tool can be used to quantify and explore the costs and risks of different scenarios (eg. key network constraints that are increasing costs, such as delays at a port facility; impact of new roads on transport costs, or the vulnerabilities to key transport networks and supply chains to natural disaster).

The following methods and steps were used to further develop and apply the TraNSIT model for each country:

- Data sourcing, compilation, summary, digitisation, integration, geospatial referencing, and warehousing. The spatial and statistical data sets and layers included administrative boundaries, road and transport infrastructure, agricultural production, agricultural import-export data, agricultural enterprises and human population and poverty rates;

- Characterisation of road network and vehicle characteristics using descriptive, statistical and modelling approaches using primary data from key informants in the transport and logistics sector, secondary published sources (e.g. World Bank reports) and analysis of GPS vehicle tracking data (in Vietnam);
- Mapping product, vehicle and transport flows along target supply chains using secondary data sources from research reports supplemented by primary data gathered during field work from key informants from government, research institutions and the private sector;
- Participatory consultation with key government, research and private sector partners and stakeholders in working meetings and workshops conducted to identify issues associated with transport infrastructure planning and decision-making and to define case-studies and scenarios for analysis;
- GIS and spatial analysis and optimisation modelling to calibrate and then run TraNSIT analyses.

Objective 2. Develop an understanding of the links between infrastructure, relationships, and institutional aspects of transport bottlenecks, and understand critical stakeholders and collaborators who will translate outputs into impact

For this objective the methods included literature reviews, country visits which included field visits, and stakeholder meetings (initially in person and post-COVD via the in-country sub-contractors). This built on the previous relationship development established as part of AGB-2016-033, but going further in developing a better understanding of how findings from case studies developed in Objective 1 could translate to impact with decision makers, the private sector, farmers, donors and other potential beneficiaries.

Objective 3. Understand the capital, skills, and equipment requirements to establish TraNSIT in Vietnam and Indonesia

Direct observation, meetings, general discussions and consultations with research partners and key stakeholders were undertaken to understand current capability, skills and equipment; and to determine requirements needed to integrate the TraNSIT modelling platform or utilise TraNSIT outputs within their institutions.

In Vietnam, a key forum to understand these was the joint CSIRO-TDSI workshops held in Hanoi June 27/28 2019, with organisation led by FocusGroupGo (refer details in Appendix 1).

Similarly, in Indonesia several workshops with BAPPENAS, Ministry for Agriculture and BPS were convened through PT Mitra Asia Lestari to understand the capacity building and IT infrastructure needs to develop, deploy, host and run the tool locally.

Objective 4. Develop a business case and proposal for a larger project

A range of consultations were conducted with key government stakeholders, businesses and potential research collaborators in both countries to identify key issues and research questions and refine a proposal concept. Discussions emphasised the potential for improved transport infrastructure and logistics to create better market access for smallholder farmers.

In Indonesia, consultation was carried out across the government agencies, state owned enterprises, private sector groups and private companies. In terms of ongoing research support BAPPENAS, the Ministry of National Development Planning, the Indonesian Agency of Agricultural Research and Development (IAARD) and the Bogor Agricultural University (IPB) were consulted and sought to actively support ongoing research while other important ministries such as Coordinating Ministry for Economic Affairs, Coordinating Ministry for Maritime & Investment Affairs, Badan Pengkajian dan Penerapan Teknologi (Agency for the Assessment and Application of Technology) and Indonesian Agency of Agricultural Research And Development as well as Badan Pusat Statistik (Statistics Indonesia) all stated a desire to participate in the development of a larger project

In Vietnam, the Ministry of Transport (MOT) and the Ministry of Agriculture and Rural Development (MARD) were consulted about strategic priorities and gaps in information or capability in relation to transport and logistics investment decision-making and market connectivity. The Transport Development and Strategy Institute (TDSI), the Institute of Policy and Strategy for Agriculture and Rural Development (IPSARD), the Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI), the Center for Informatics and Statistics (CIS) and the National Institute of Agricultural Planning and Projection (NIAPP) were identified as potential research partners and provided input into the concept. The World Bank, the Asian Development Bank, and the Aus4Transport development program funded by the Australian Department of Foreign Affairs and Trade (DFAT) were also consulted.

7 Overview of TraNSIT

TraNSIT (Higgins et al., 2015; Higgins et al., 2017) is a modularised tool (Figure 7.1) where data for a commodity supply chain is an input to the core engine (green cylinder in Figure 7.1), along with the infrastructure or regulatory scenarios to test. TraNSIT is programmed in Python (www.python.org) and uses the ESRI ArcGIS network analyst capability while accommodating multiple features about the road (and/or rail or ship) network. Transport network data are critical and roads of different rankings (e.g. primary, secondary and minor (including unsealed)) are included.

In this project, a road layer for Indonesia and Vietnam was initially sourced from Open Street Map (OSM) (http://maps.elie.ucl.ac.be/CCI/viewer/download.php). Additional information defining ranking, access restrictions and other road information was incorporated. The road layer required enhancements (e.g. creating connections, correcting locations of some roads) to provide a fully routable road layer suitable for subsequent modelling. This network was subsequently replaced with a purchased commercial, routable network (provided by HERE, https://www.here.com/en), which contains a more detailed road and trail network (particularly in rural areas), and reduced the time required to conduct scenarios and broader applications of TraNSIT. The HERE network also contains additional features including average speeds (by vehicle type), road conditions (sealed, narrow sealed, unsealed) and other features (heavy vehicle access restrictions, bridge limits) that impact travel costs and vehicle routes. For Indonesia, the HERE road network also contains shipping lanes between islands. The major routes represented by the HERE network data for Indonesia and Vietnam are shown in Figure 7.2 and Figure 7.3 respectively. Due to HERE licence restrictions (the license was not renewed at the end of the data analysis), more recent analyses have used the Open Street Map network data, which is free and can be accessed by partners and collaborators without a license.

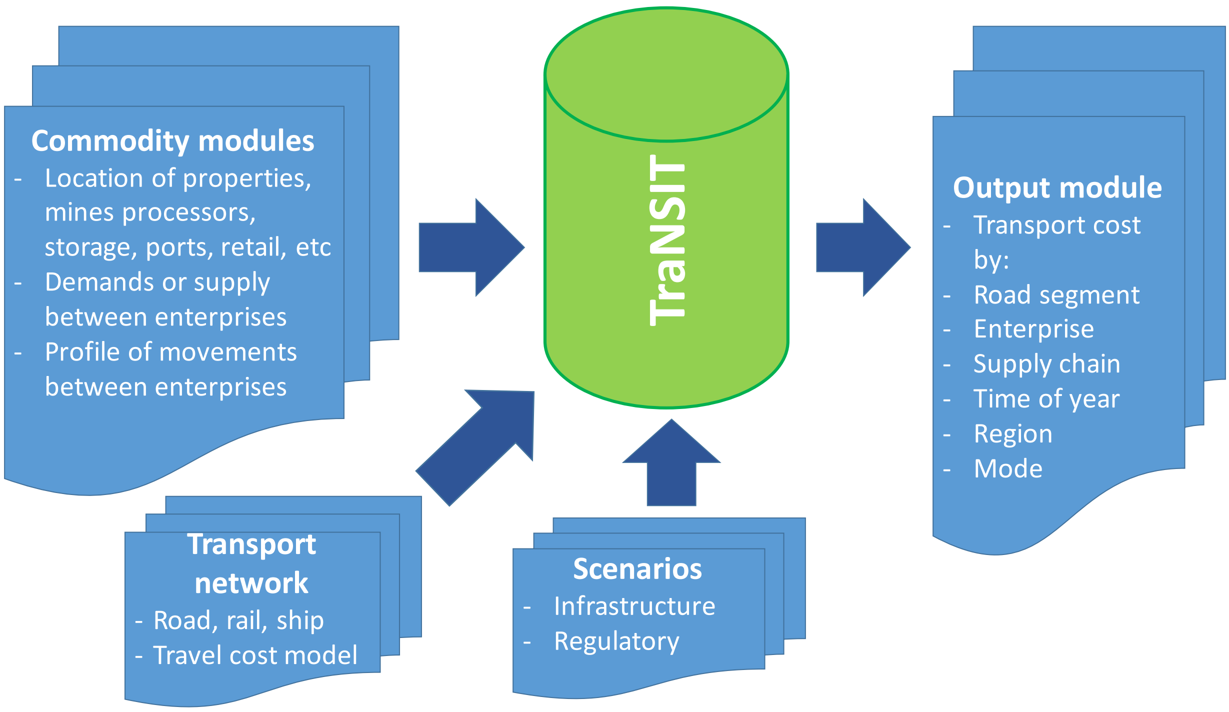

Figure 7.1 Components of TraNSIT

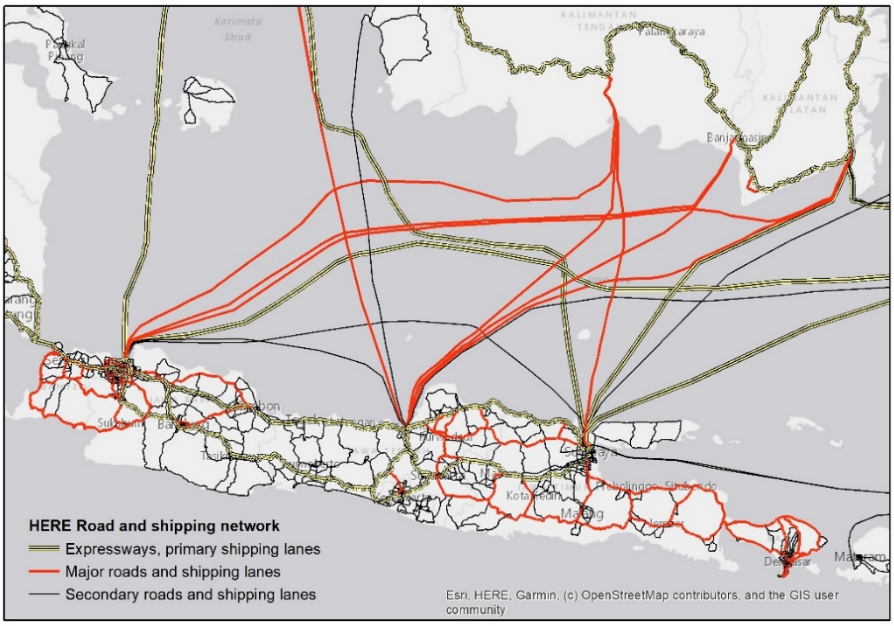

Figure 7.2 Major roads and shipping routes in and to/from Java, Indonesia, based on the HERE (2019) road and shipping network

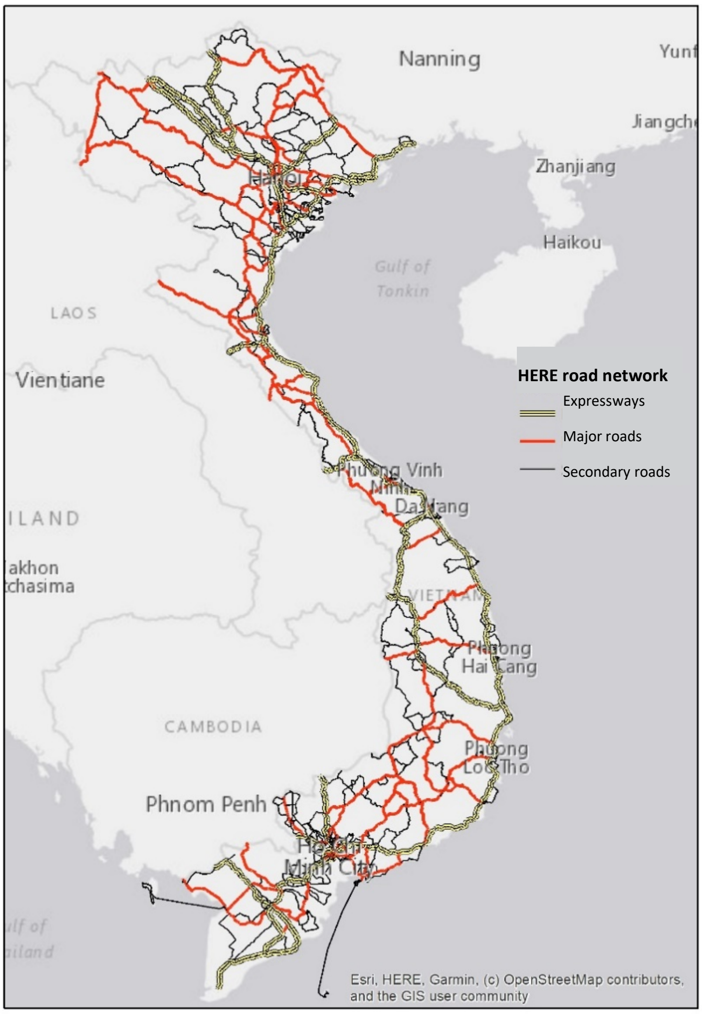

Figure 7.3 Major roads in Vietnam, based on the HERE (2019) road network

TraNSIT uses a ground-up costing model for road, rail and shipping. For road, it is based on published equations for vehicle operating costs (Tan et al., 2012; QDTMR, 2011). Additional vehicle types for Indonesia and Vietnam were incorporated after being identified through meetings with in-country stakeholders such as the Indonesian Trucking Association. The vehicle operating cost model was parameterised for Indonesia and Vietnam using data and published information provided by in-country stakeholders. The costing model was enhanced for different types of unsealed roads, accommodating additional maintenance costs for vehicles. The costing models were validated and refined in 2019 through feedback from stakeholders (e.g. Indonesian Logistics Association) and published reports (e.g. World Bank, 2014, Lam *et al.* 2019). Loading and unloading time and costs are enterprise-specific and are included in the freight travel time and cost, as are vehicle decoupling times and costs. All of these costs are incorporated within TraNSIT, allowing identification of the best freight combination for the specific freight task.

TraNSIT simulates the number of vehicle trips 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/shipping 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. Included in the modelling are cost trade-offs for choosing between less than optimal routes in terms of distance and preferred routes due to driver preference or commodity needs. The least-cost vehicle combination selected depends on heavy vehicle access restrictions throughout the journey from origin to destination.

Since a farm or paddock 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 point on the road segment closest to the origin, and finish at the point on the road segment closest to the destination point. This process is repeated for all routes, always searching for the minimum cost route and selecting it as the optimal route. This has presented challenges in the development of the models for Indonesia and Vietnam, where land use is a complex and complicated dissection of landscape, as opposed to the Australian experience where farms and boundaries are well-defined. For Vietnam and for rice in Indonesia, we determined production locations based on the definition of cropping landscapes according to a global satellite-derived landcover dataset. For sugar production data in Indonesia a production map was sourced from the Ministry for Agriculture and data extracted from the map using georeferencing techniques, while for sugar processing and cattle a manual data collection exercise was completed by PT Mitra Asia Lestari using publicly available data and google maps to locate the enterprises.

TraNSIT maps supply chains and tests impacts of changed transport-related logistics, including:

- Benchmarking existing logistics of key commodities, identifying bottlenecks from paddock to plate;
- Evaluating and optimising logistics arrangements from production, through processing and storage (including centralised warehousing options) to retail in order to ensure efficient operation from paddock to plate;
- Prioritising investment and identifying inefficiencies;
- Identifying critical infrastructure and testing upgrades to transportation route infrastructure, including road improvements, bridge construction, ports and shipping routes;
- Providing transport freight flows and costs and testing impacts for upgraded fleets including truck, train and ship fleets; and
- Providing costs and freight flows for policy settings and testing policy changes.

A 2-page fact sheet on the project was produced for Indonesia and Vietnam to introduce stakeholders to a high-level and non-technical overview of the project (see Appendix 11.2).

8 Achievements and results against objectives

8.1 Objective 1. Further develop the adapted TraNSIT models for scenarios in Indonesia and Vietnam

8.1.1 Development of prototype model

The proof of concept developed showed that the technology was capable of providing valuable decision support around potential investments in transport infrastructure applied through different scenarios. The model development generated considerable interest from agencies and industry when the utility of the model was demonstrated, and this user interest led to the model being progressed from proof of concept which tests the technological feasibility to a prototype which includes user interaction and experience elements and explores the implementation challenges following the application design (Figure 8.1). The focus in this project was aimed at the design and production domains seeking to ensure broad capability, flexible design and maximum functionality for the analytical interface. Steps were taken to complete elements of the development task recognising the importance of system integration to allow data security to remain paramount but also to enable sharing where appropriate.

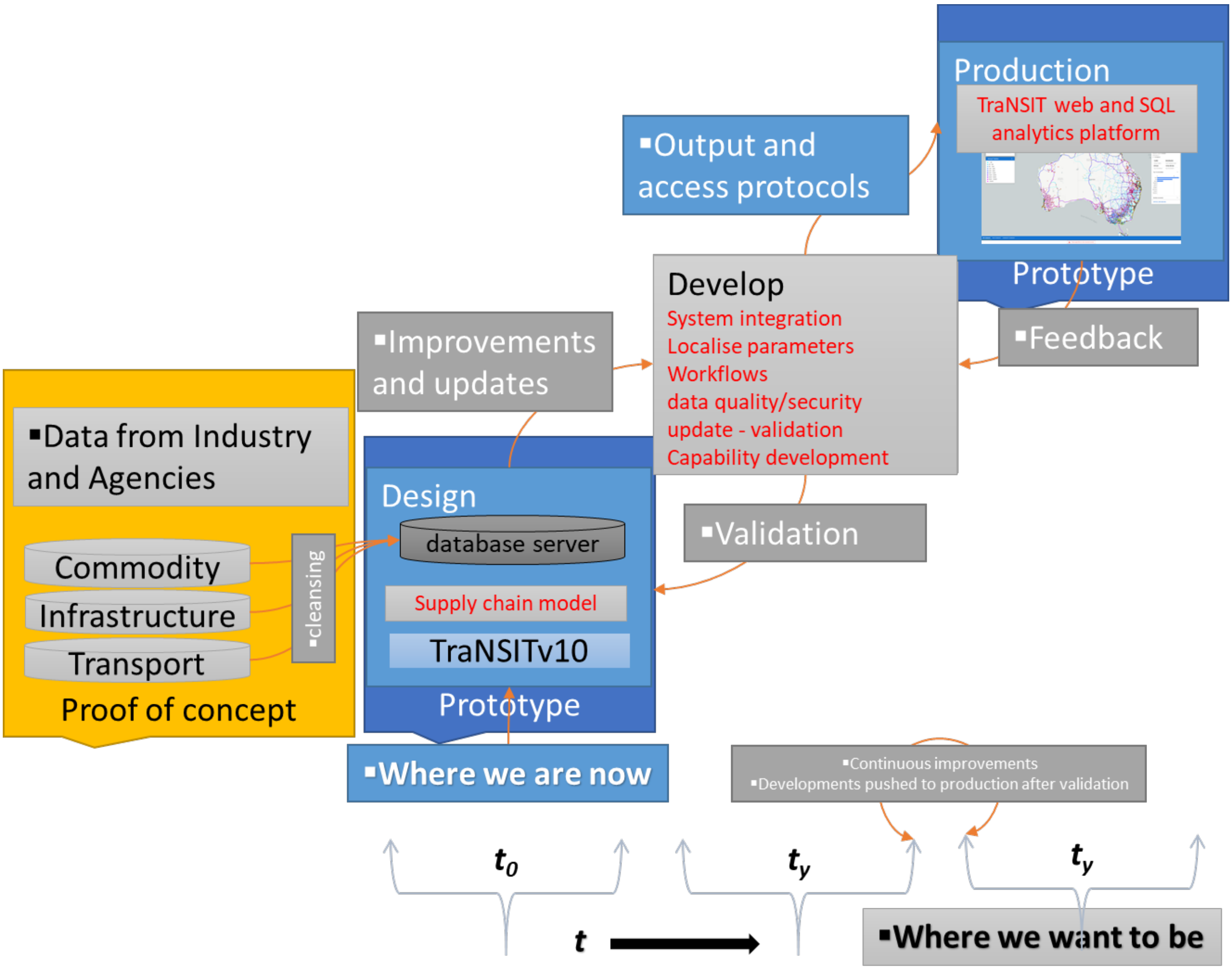

Figure 8.1 TraNSIT production design

The prototype model has been created in a python development platform using a PostGIS spatial database in a PostgreSQL database to support data inputs and outputs. The model uses the Vietnam_Q2_2018_WGS84 HERE and Indonesia_Q2_2018_ WGS84 HERE network. Testing has begun to incorporate the OSM data into the model to avoid the need to have license access to the

HERE network. Modification to the sea routes were made to map to Indonesia Sea Toll Strategy Framework (at www.bappenas.go.id/files/Pengembangan%20Tol%20Laut%20Dalam%20RPJMN%202015-2019%20Dan%20Implementasi%202015.pdf)

Vehicle operation cost models (VOC) for the operation of transporters, both sea and road, were developed that captured the total cost and time for transport and logistics. For the prototype model, three truck models and three ship models were developed which included logistic costs, the fixed and variable costs including capital costs, and the logistics time.

The transport costs for different speeds and vehicles are provided in Table 8-1 and Table 8-2 for Indonesia and Vietnam, respectively. Indonesia is heavily reliant on shipping between islands, particularly transporting agriculture from western Indonesia to Java. Shipping lanes are included in the transport network (Figure 7.2). Some shipping and port costs were obtained from state-owned enterprises such as P.T Pelni in Jakarta (P.T Pelni are the State-owned national shipping company for Indonesia). A prototype shipping module was produced in late 2019 (based on operating costs provided in Table 8-3).

Table 8-1 Summary of transport costs for some typical vehicles in Indonesia at various average speeds

	Modelled cost (Rp/km) per travel speed (sealed roads)			Modelled cost (Rp/km) (unsealed roads)	
Type	100 km/h	60 km/h	20km/h	60 km/h	20km/h
Suzuki Carry	2,988	3,363	5,915	3,525	6,301
Colt Diesel	4,960	5,389	8,647	5,686	9,302
8 Tonne Fuso	6,806	7,308	11,298	7,768	13,162
Trontonne (4 axel)	8,323	8,990	14,094	9,771	14,874
Semi-Trailer	9,839	10,428	16,390	11,380	18,984

Source: Derived from key informant interviews and stakeholder

Table 8-2 Summary of transport costs for some typical vehicles in Vietnam at various average speeds

	Modelled cost (VND/km and USD/km) per travel speed (sealed roads)			Modelled cost (VND/km) (unsealed roads)	
Type	100 km/h	60 km/h	20km/h	60 km/h	20km/h
Small truck (tonne)	8,180 (0.36)	8,900 (0.39)	14,260 (0.62)	9,380 (0.41)	15,340 (0.67)
Large truck (20 Tonne)	15,480 (0.67)	17,200 (0.75)	27,040 (1.18)	18,780 (0.82)	31,310 (1.36)

Source: Lam *et al.* (2019)

Table 8-3 Draft Shipping operating costs (AU$/tonne or TEU) for a 250m ship with a payload of 40,000 tonnes

Vessel Type	500km	1000km	2000km	4000km	8000km
Bulk dry	$4.73	$5.97	$8.43	$13.36	$23.22
Bulk fuel	$4.71	$5.92	$8.34	$13.17	$22.84
Cargo	$4.34	$5.19	$6.87	$10.24	$16.98
Container (TEU)	$170.93	$201.80	$263.53	$386.99	$633.91

Source: Derived from key informant interviews and stakeholder

The supply chain data are used as inputs to the trip module which allocates tonnages between an origin enterprise and destination enterprise. This process results in a synthetic set of movements along the supply chain that reflects the status of the system. This method gives the tool considerable power when carrying out scenario modelling to test changes in the supply chain - either to production, processing, distribution, or consumption.

Model runs require data for the supply chains and VOC to be accessed and these are combined with the transport network to generate trip routes and costs. The model optimises the route between origin and destination (referred to as O-D) and identifies the best vehicle configuration to use given the trip path and commodity/tonnage to be moved.

A web interface (Figure 8.2) has also been developed to enable users to both analyse the model outputs and see statistics and metrics on selected transport freight task. TraNSIT.id web and TraNSIT.vn web contain a map that displays the tonnage of commodities moving along the transport network. Built into the interface are filters to allow the user to drill down and capture details across several dimensions including roads, commodity, enterprise or region or any combination of them.

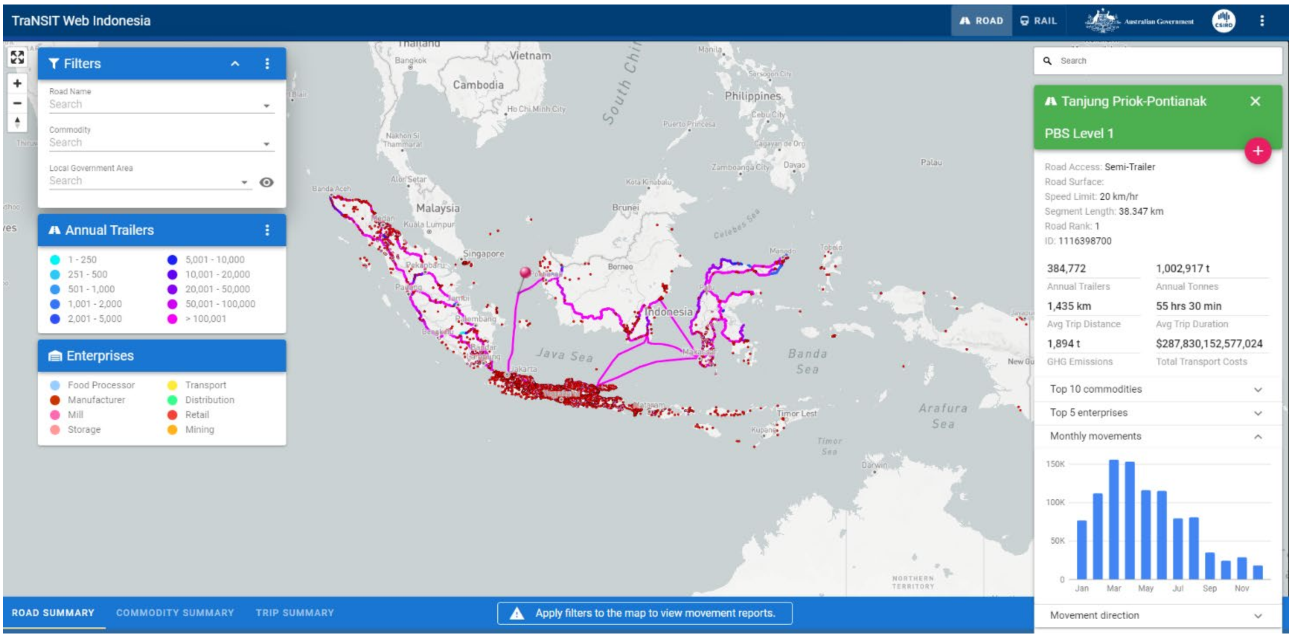

Figure 8.2 Web interface to enable analysis of the modelled data

The major goal was the development of a prototype model, set up to allow ongoing technical and project effort to capture supply chain data to improve the trip module and to continuously update and improve the model parameters and vehicle configurations. With the prototype model develop, national datasets for Indonesia and regional datasets for Vietnam could be collected, as outlined in the next sections.

8.1.2 Indonesia

Datasets

The TraNSIT model requires data for commodities, supply chains and logistics as well as data for transport networks and transporters. Identifying data sources and securing access was of prime importance. During this project considerable resources was directed towards this activity though stakeholder engagement and follow up. The consultation process involved numerous meetings, workshops, and field trips with government representatives at multiple levels as well as national organisations, commodity groups, transport and logistics operators and local farmers.

This section primarily focuses on results for the rice baseline and scenarios. For cattle and sugar, production data (animal numbers) have been gathered for Java, East Nusa Tenggara and Lampung at the scale of *kabupaten* (district). Processing and feedlot information has not yet been gathered at a high level of spatial granularity. Data for sections of the cattle and sugar supply chains were collected, testing alternative methods for data collection. For sugar production, georeferencing publicly available production maps was tested, resulting in wide area maps of sugar production regions. For sugar processing and cattle feedlot and processing data a manual process was tested which included researching enterprises and using google maps to locate.

The rice supply chain is analysed and present below.

Rice

The application of the rice supply chain scenario was designed to understand the types of data that could be used to enable the modelling and to identify limitations in data access, and as rice was the most complete dataset available (and which the stakeholders showed most interest in understanding) we used it as a precursor to test the model application. Rice is also of value due to the importance of the commodity nationally as a staple food and its broad production regions.

Detailed production and processing data have been gathered for rice with production data collected from the Ministry of Agriculture. Data were captured by Landsat 8 and extracted from PDF files (http://sig.pertanian.go.id). The location data was linked with production data (hectares) at Kecamatan scale for all Indonesia, to infer production tonnes for each cropping cycle. The main reason for aggregating to this level was to reduce the computational overheads for the case study example. The data collected on the rice supply chain throughout Indonesia was run through the model.

The rice scenario involved 64.4 million tonnes of annual production across 4130 representative production locations totalling 12.7MHa and approximately 15 million small holder farmers. Province-level production data was sourced from the Indonesian Ministry for Agriculture; and farm number and locations were determined from average yield per farm of 4.77 T/Ha on average allowing for the higher yields achieved in Java, with cropping land derived from Ministry of Agriculture through their Landsat 8 Esri ArcGIS web server (https://www.arcgis.com/apps/View/index.html?appid=4eaddbb9ad5b4c8d919ddd753ca8c853&extent=96.8046,-13.4062,138.1132,7.9553).

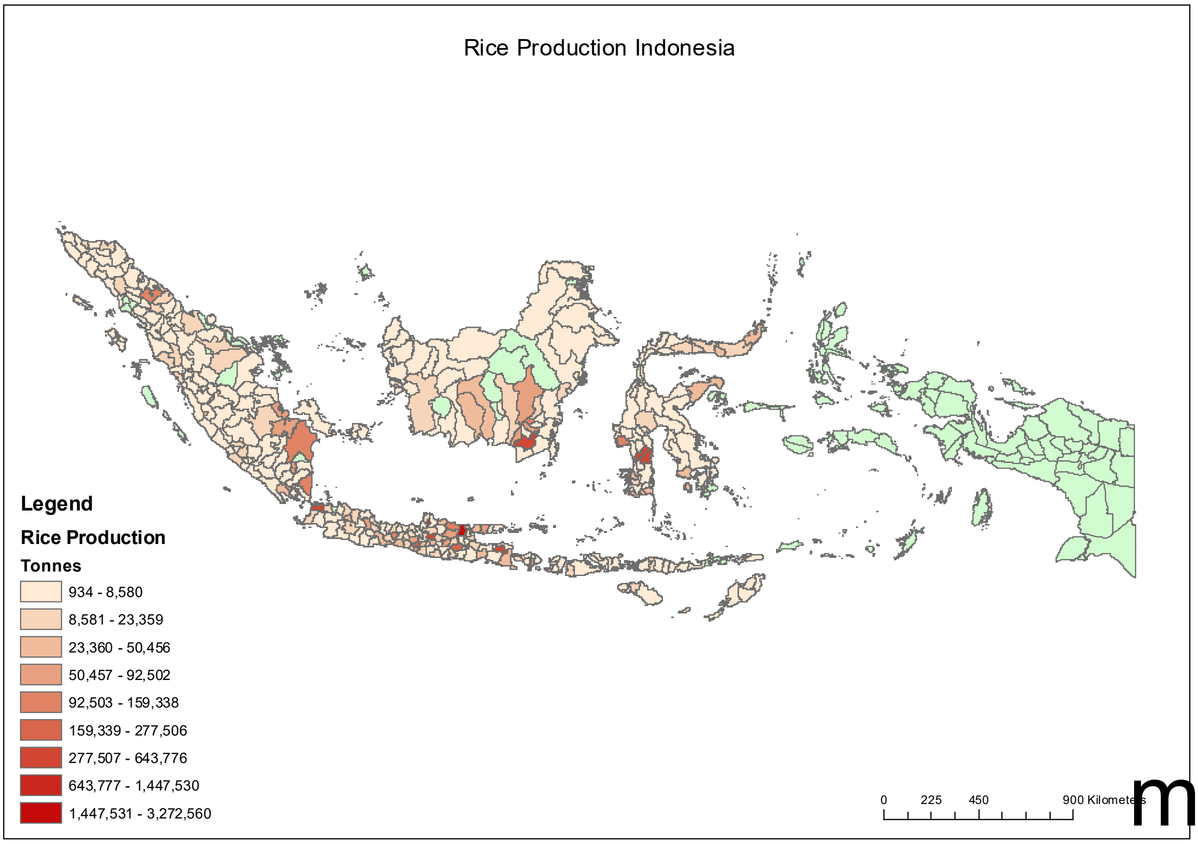

Figure 8.3 Indonesia rice production (green – no production)

Monthly rice production was projected based on harvest cycles and timing for each region. Figure 8.4 shows the distribution of harvest and rice production across the country.

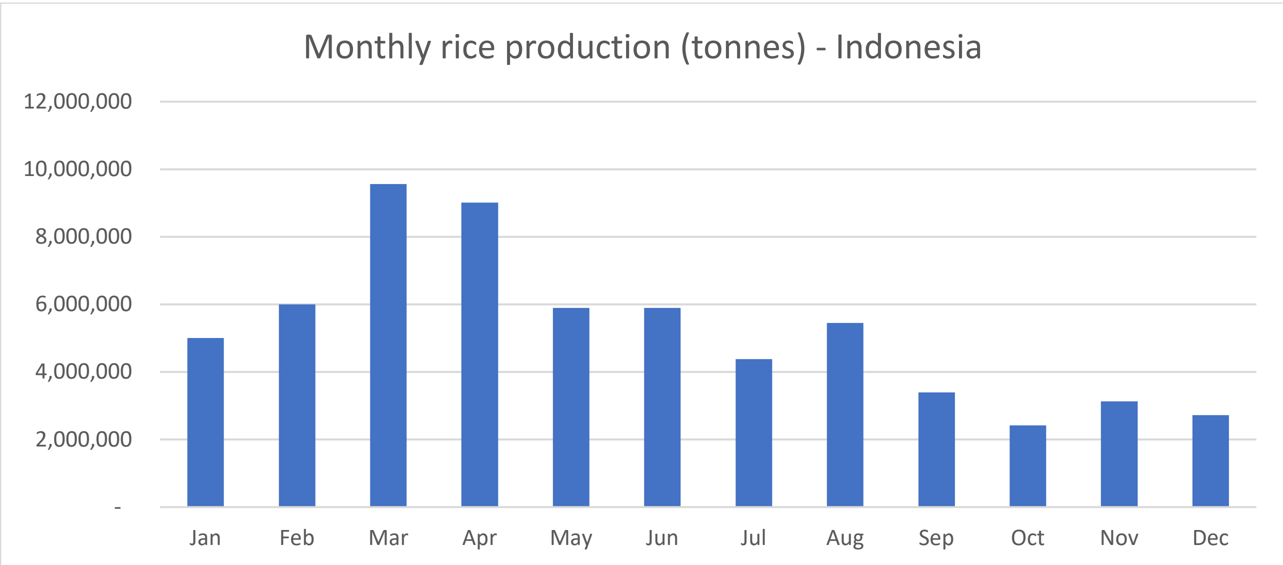

Figure 8.4 Monthly rice production Indonesia (Tonnes)

Once harvested, rice is transported to one of the many rice mills located in the country. These mills range in size and processing capacity, and for the purpose of the modelling these mills were represented as 992 processing enterprises located near the production regions (hence providing the destination for the O-D movements). Given a production yield of approximately 65%, yield from the rice mills, about 40 million tonnes of milled rice was then moved to rice wholesalers and markets. Consumption was estimated as 150kg per person per year with market demand determined by population count (2016) for the 4,592 points representing the 7,024 *Kecamatan* *(subdistrict)* across the country. This rice is supplemented by 500,000 tonnes of imported rice which is mostly distributed through BULOG (the Indonesian Logistics Bureau).

Table 8-4 Rice tonnages

Commodity class O-D	Total Tonnes
Rice (transported)	**62,893,600**
Property	**62,893,600**
Rice Mill	62,893,600
Bag Rice (transported)	**78,980,769**
Port	**500,000**
Rice Storage	500,000
Rice Mill	**38,994,032**
Rice Storage	38,994,032
Rice Storage	**39,486,736**
Market	39,486,736
Total (transported)	**141,874,369**

Overall, as shown in Table 8-4, for our model, a total of 141 million tonnes was moved across the supply chain, represent by 63 million tonnes of hulled rice production moved to mills resulting in 39 million tonnes of milled rice moved on to storage and market. Additionally, 0.5 million tonnes of imported rice was included in the modelling. The supply chain is represented in Figure 8.5.

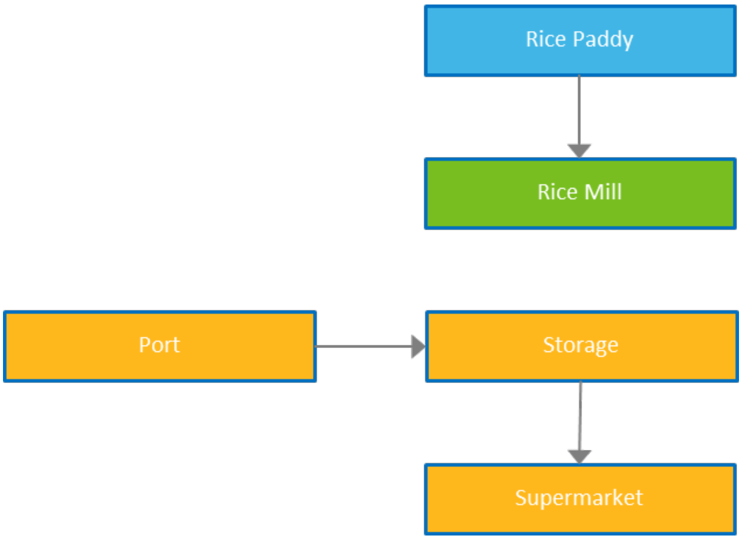

Figure 8.5 Diagram of the basic rice supply chain in Indonesia

While there is considerable variation in the logistics across the country it was decided for the purpose of the protype development and modelling the average vehicle payload from farm to processor would be set at 2 tonnes, 20 tonnes between processor and warehouse and 10 tonnes to market (Noting that this could be varied in future scenario testing where more accurate information was available).

Baselines

Baselines provide information on the current tonnage and costs of commodity movement across the road network for the whole supply chain from production to processor to market/export, based on the least-cost route for each commodity movement.

Rice

The supply chain data along with the assumed vehicles parameters were uploaded to the trip module and resulted in 74,000 supply chain movements leading to over 30 million vehicle trips per year. These trips were modelled through TraNSIT.id providing insights into the paths used to move the rice across the supply chain (Figure 8.6). The data were able to be analysed through the web interface as shown in Figure 8.2.

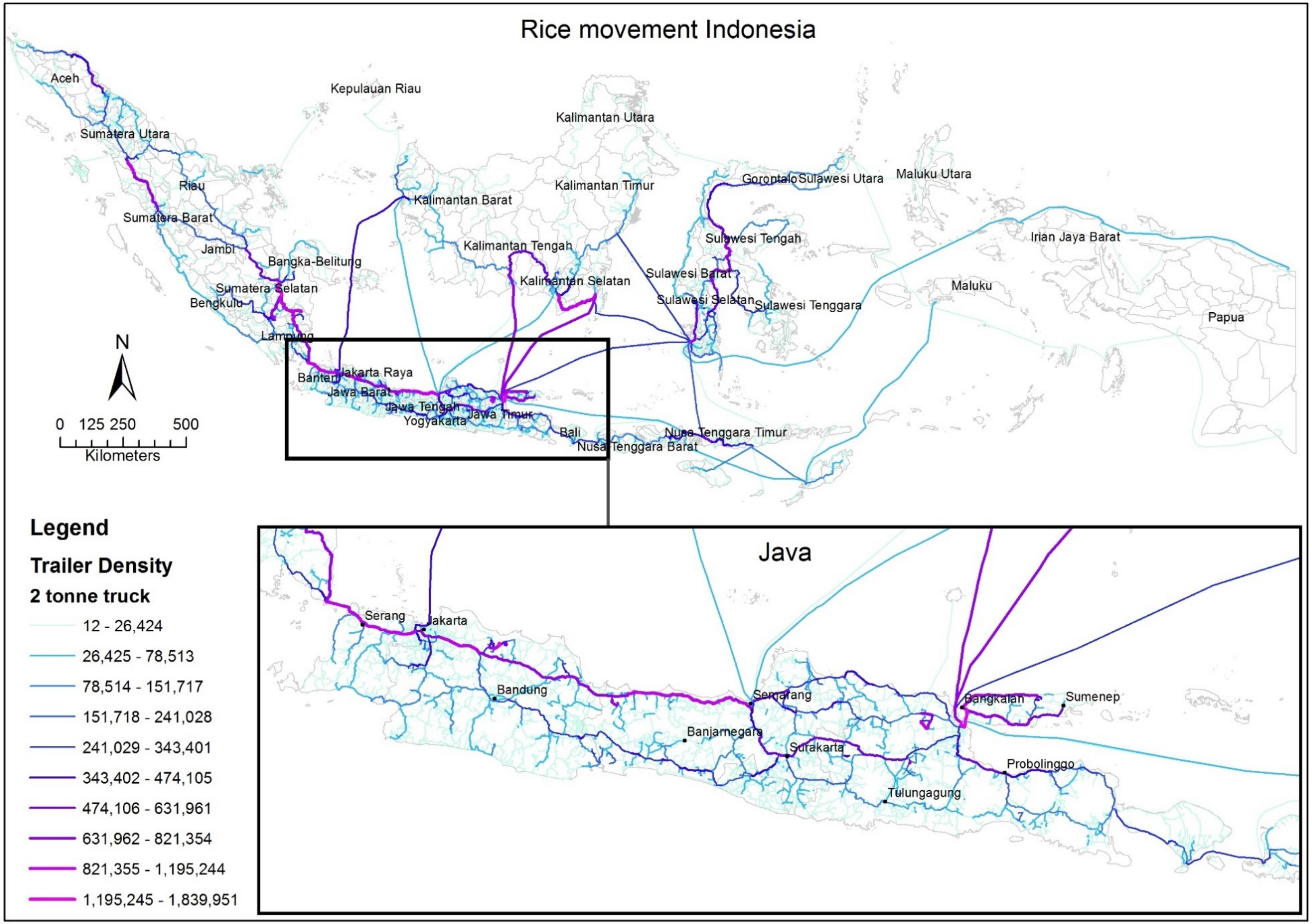

Figure 8.6 Vehicle density (annual trailers) for transport of rice across Indonesia, from farms to processors and markets (inset Java)

The main observations are the heavy freight demand along the major toll routes and along the sea toll routes particularly to Kalimantan and Sulawesi and between Java and Sumatra. Also of note are the impact on road infrastructure in the regions where the rice are harvested and transported for milling and on to storage, these enterprises have both an input flow and an output flow and as such have twice the transport and logistics relative to enterprises at the ends of the supply chain and can often be a bottleneck in the system. The importance of quality first and last mile access to these enterprises can impact greatly on the efficiency for the commodity supply chain flows.

Scenarios

Java rice road disruption scenario

This scenario focused on production and distribution of rice in east Java using the supply chain data gathered for the region and covering 1.6 million hectares of production land. A summary of the scenario inputs is contained in Table 8-5. For this scenario, average yield was estimated to be 4.77 tonnes per hectare based on data captured from Ministry for Agriculture summaries from satellite data analysis (http://sig.pertanian.go.id/pdf/) with an average of 1.5 crop rotations per year across all areas of production based on expert opinion elicited from BPS and Ministry of Agriculture. Rice transport was mapped from production location to the nearest rice mill, followed by transport to rice storage facilities (Figure 8.8). In the absence of data on location of specific markets, rice was assumed to be transported from the storage facilities to the centre of each *kecamatan/desa* (subdistrict/village) with rice demand being a function of population at each of these 3,226 locations in Java (Figure 8.9). Transport routes and volumes to each of these *kecamatan/desa* is expected to be representative of transport to markets. Typical vehicles for the supply chain legs are shown in Table 8-5. The supply chain paths represent the number of unique O-D routes. The 29,000 supply chain paths to markets mean that each of the 3,226 market locations receives rice from an average of nine storage sites.

Table 8-5 Characteristics of enterprises and supply chain for rice scenario in Java

Enterprise	Number	Total area (hectares)	Supply chain paths	Truck type and payload
Production location	971	1,632,944		
Rice mills	702		3,494	Suzuki Carry (2 tonnes)
Rice storage	154		507	Fuso (10 tonnes)
Market locations	3,226		29,611	Fuso (10 tonnes)

Figure 8.7 shows the rice production areas and volumes for Java. At the time of the initial scenario, data were limited to central and east Java. Data on the location of rice storage and mill facilities were not available in a digital georeferenced form, and so were manually entered into ArcGIS after being located via Google Earth added by the project team after some discussion with provincial agricultural officials. About 1,000 rice mills and 700 storage facilities were included.

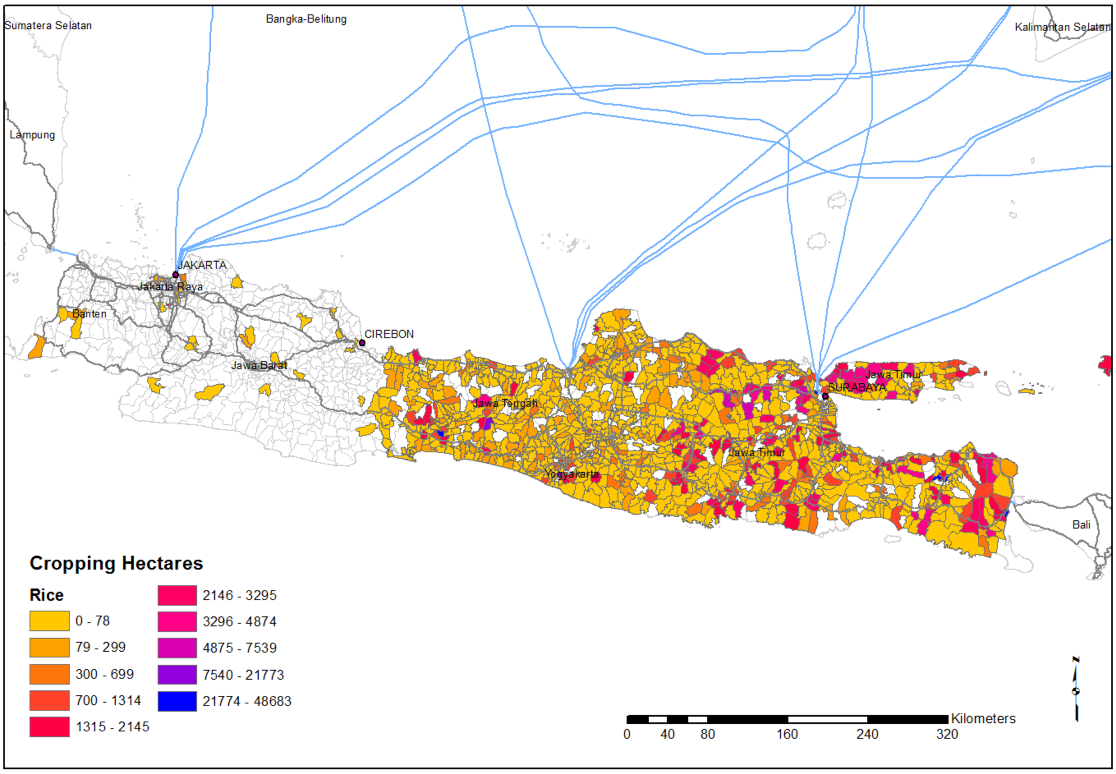

Figure 8.7 Rice production areas for scenario in Java

Table 8-6 contains a summary of outputs from TraNSIT for the rice scenario, showing transport costs, average travel time and distance. The total cost of 10 trillion Indonesia Rp equates to about AU$1 billion. Figure 8.10 shows the annual number of vehicle trips along the road network from farm to market, as produced by TraNSIT for the rice scenario. The long distances between the major production locations and population centres (e.g. East Java to Jakarta) result in high volumes of traffic along major freight corridors. Figure 8.11 shows a subset of these movements, from farm to rice mill only, which are much shorter up-country movements. These trips predominantly use a smaller vehicle (e.g. Suzuki Carry) travelling at slower speeds.

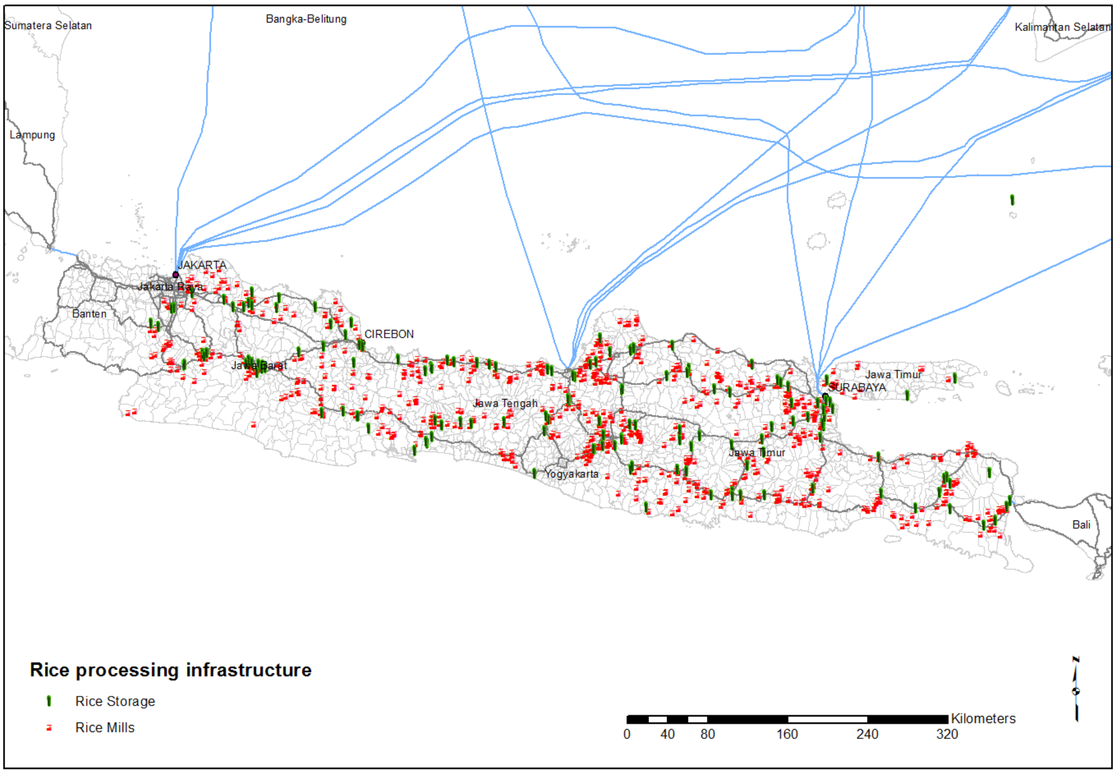

Figure 8.8 Location of rice mills and storage facilities used in the scenario (as presented in Table 8-5)

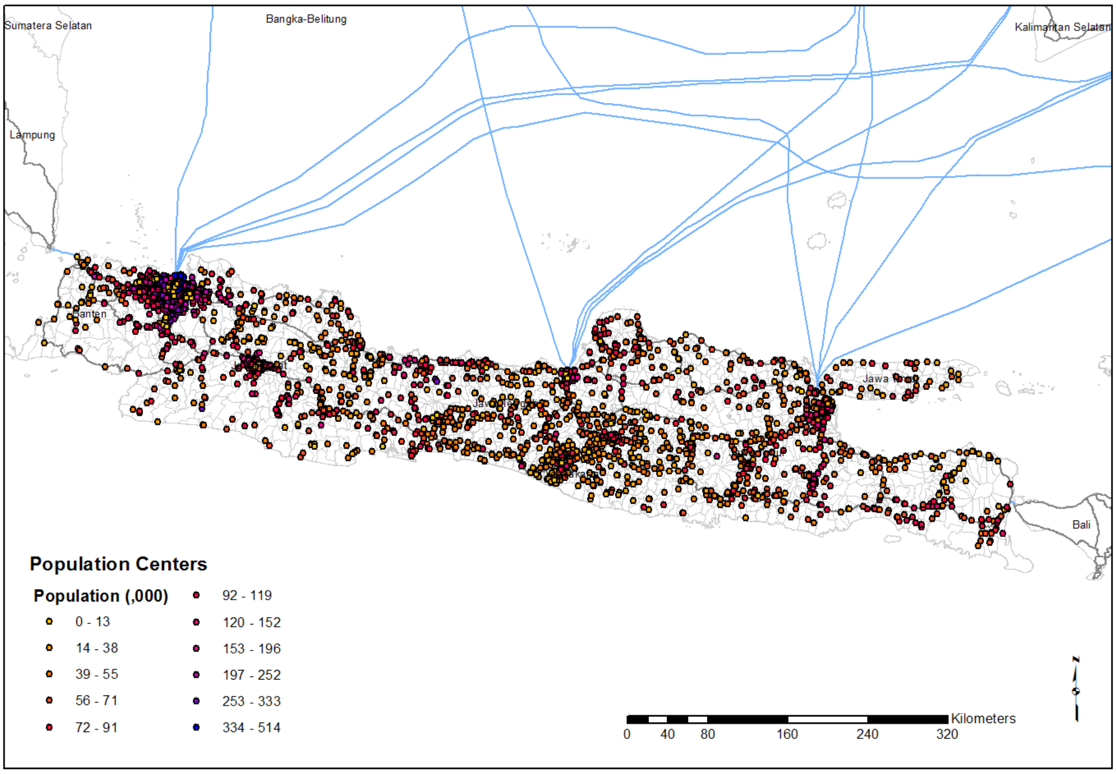

Figure 8.9 Location of the representative markets based on *desa/kecamatan* population statistics (2006), used as a surrogate for rice markets assuming 114 kg per person per year

Table 8-6 Summary of transports costs produced by TraNSIT for the rice scenario, Java

	Number of vehicle trips	Average distance (km)	Average travel time (hrs)	Total cost (billion Rp)	Av Cost per trip (thousand Rp)	Av cost per tonne (Rp)
Farm to mill	11,463,000	28	0.80	2,356	205	103
Mill to storage	1,096,400	25	0.66	471	428	43
Storage to market	1,046,074	362	7.35	7,278	6,957	696
Total	13,605,474			10,106		

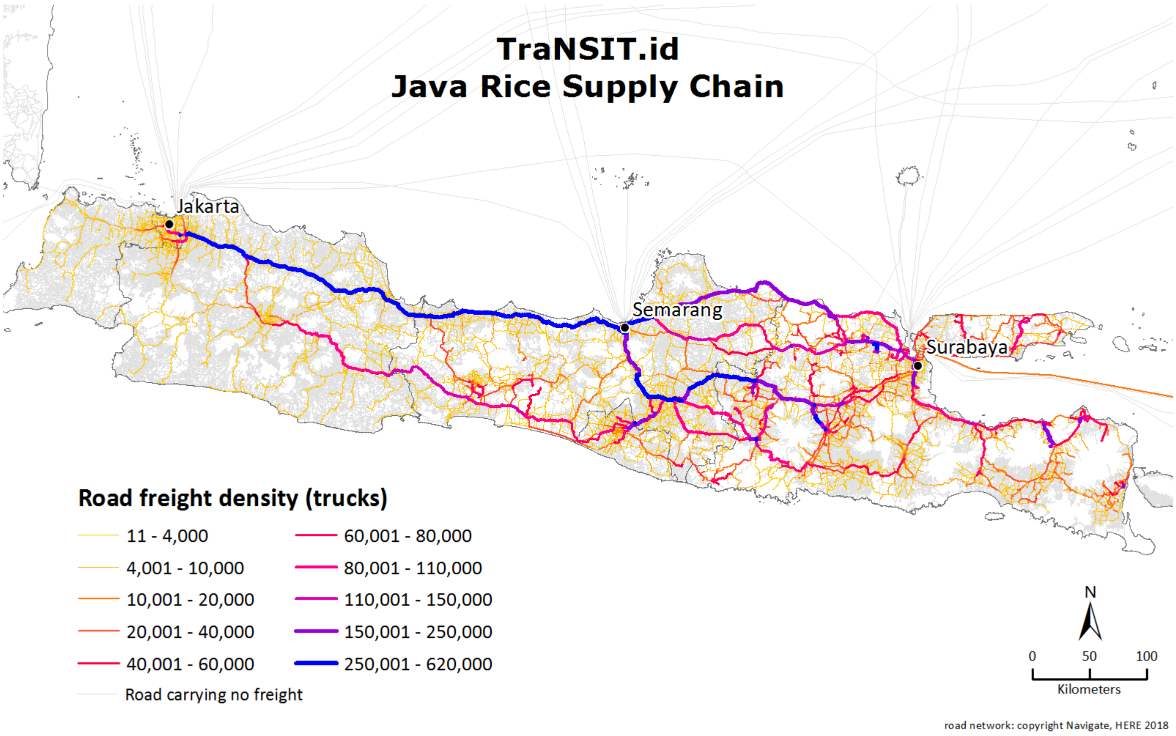

Figure 8.10 Annual number of rice trucks on the Java road network, from production to market

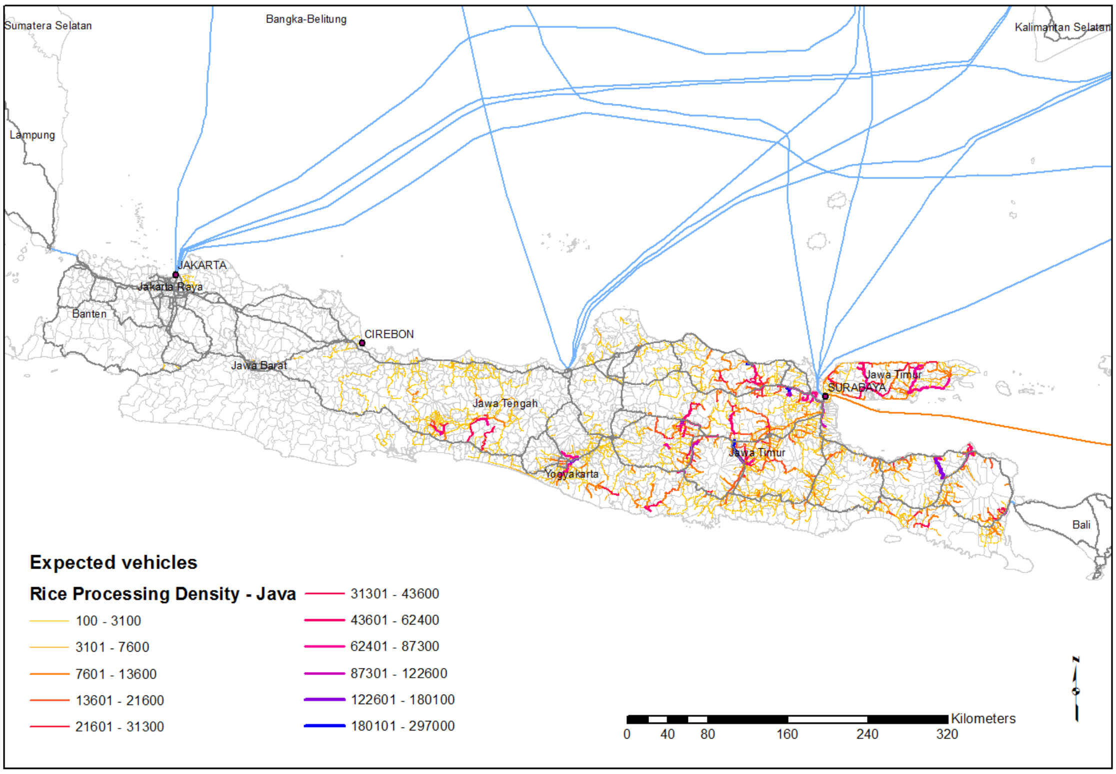

Figure 8.11 Annual number of rice trucks on the Java road network, from production to rice mill only

After consultation with a range of stakeholders with regards to areas with high vulnerability to inundation, river flooding and tidal flooding, the Semarang Coast region was selected to develop a scenario. The scenario was tested where the major freight corridor east of Semerang was disrupted due to bridge closures caused by flooding, forcing vehicles to take a major detour (Figure 8.12). The scenario was selected as there had been road closures due to flooding and coastal inundation and as such was a circumstance familiar to the stakeholders and likely end users. The impacts of sea level rise and coastal inundation are considered one of the most serious natural hazards across Indonesia (Marfai et al., 2008) and the impacts and disruptions at Semerang have been previously documented (Buchori et al., 2018).

The 43km detour (green route) results in an increased travel time of 71 minutes. The average additional cost per rice truck is Rp 1,043,223. For the 2000 rice trucks using the road segment per day, the daily cost of the disruption is Rp 2.1 billion, or AU$210,000. If disrupted for a whole year, the additional transport cost would be $76 million.

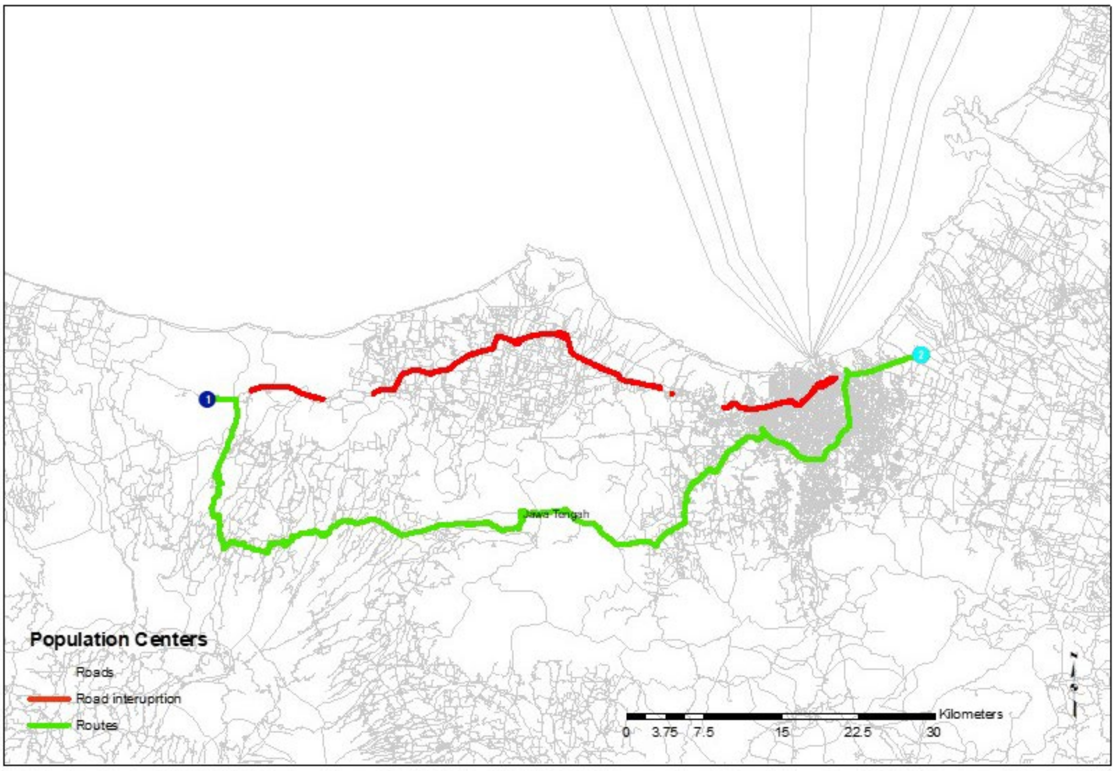

Figure 8.12 Modelled alternative route (green) for rice transport, following disruption to usual route (red) due to bridge closures

8.1.3 Vietnam

Below, a series of baseline and scenario analyses demonstrate how the TraNSIT model was adapted for use in Vietnam.

Datasets

In Vietnam, the study focused on Son La Province in the north-western mountainous region of Vietnam. Input data was sourced, and modelling scenarios were conducted at three administrative scales: province, district, and commune levels. Figure 8.13 shows the districts and road network in Son La Province. Figure 8.14 and Figure 8.15 show the communes and road network in the two focus districts of Mai Son and Moc Chau.

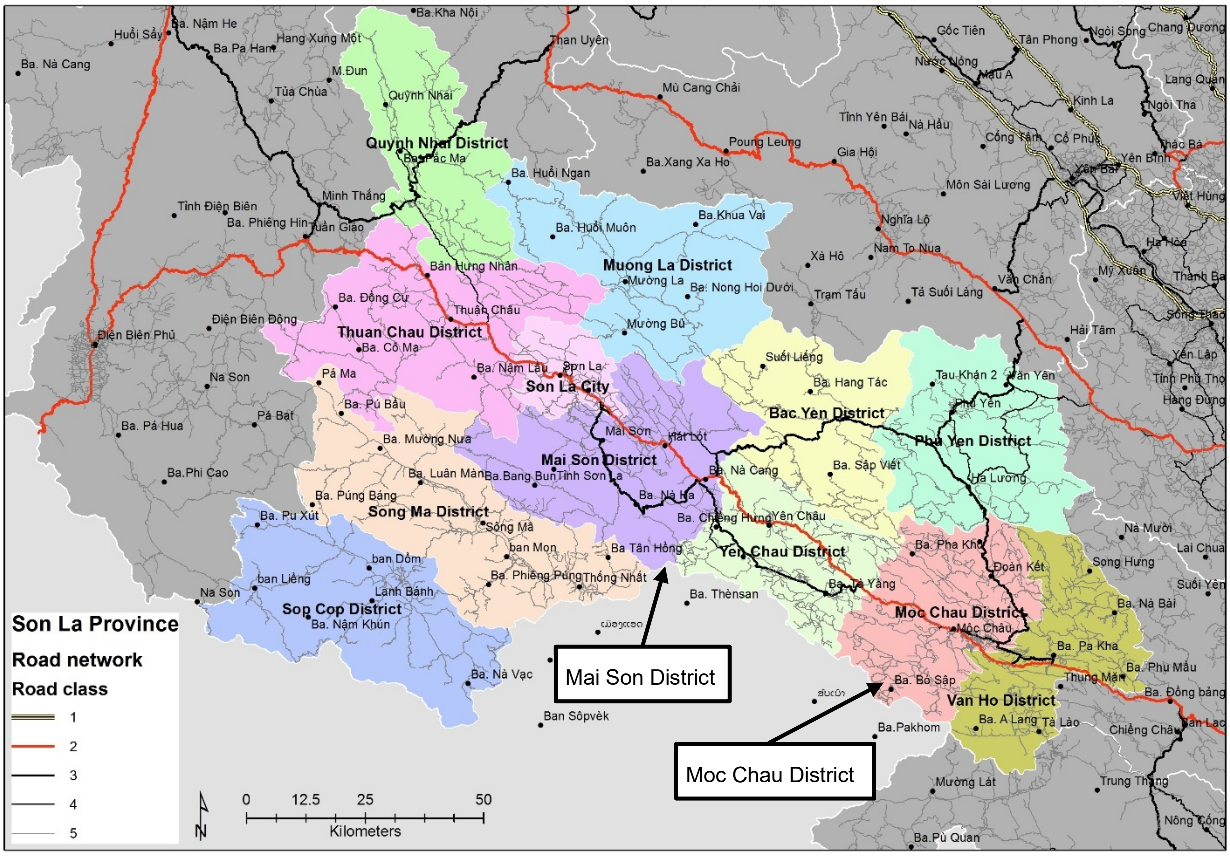

Figure 8.13 Districts and road network, Son La Province, Vietnam

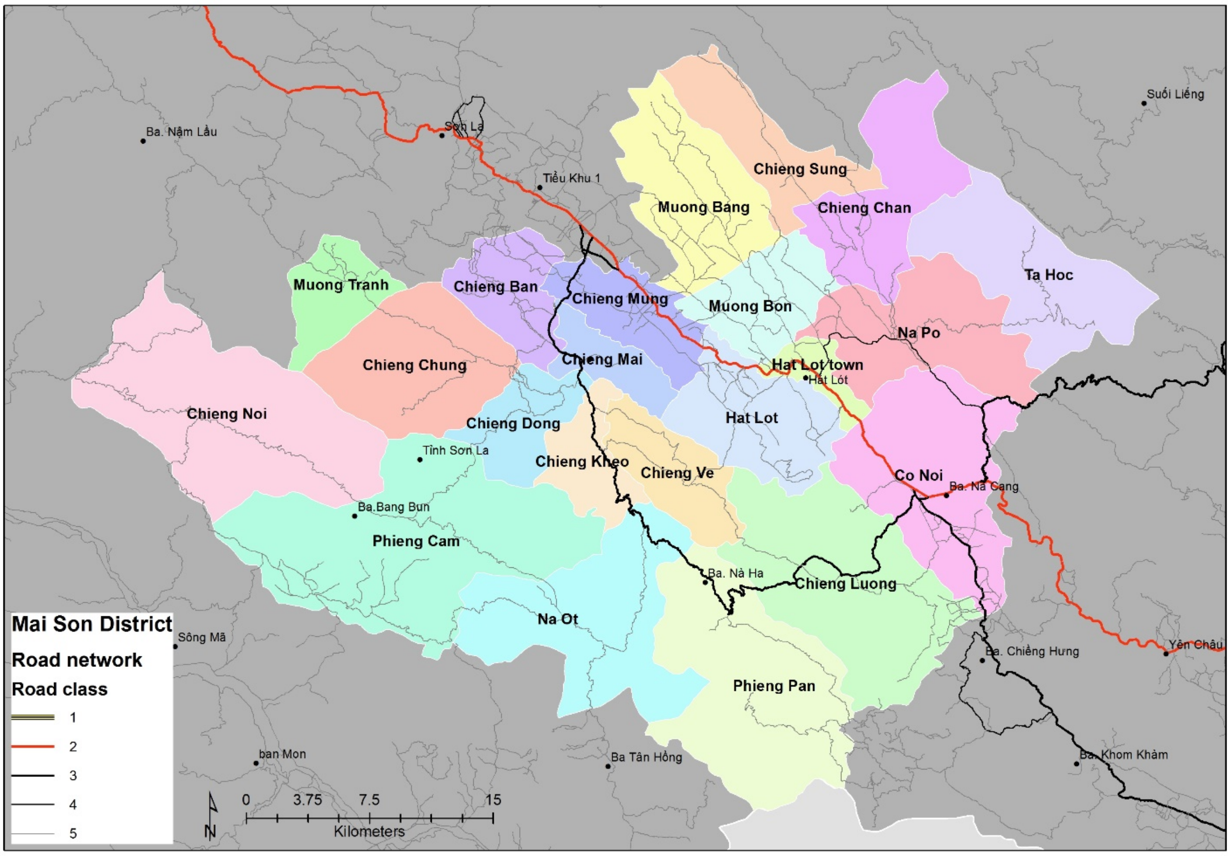

Figure 8.14 Communes and road network, Mai Son District, Son La Province

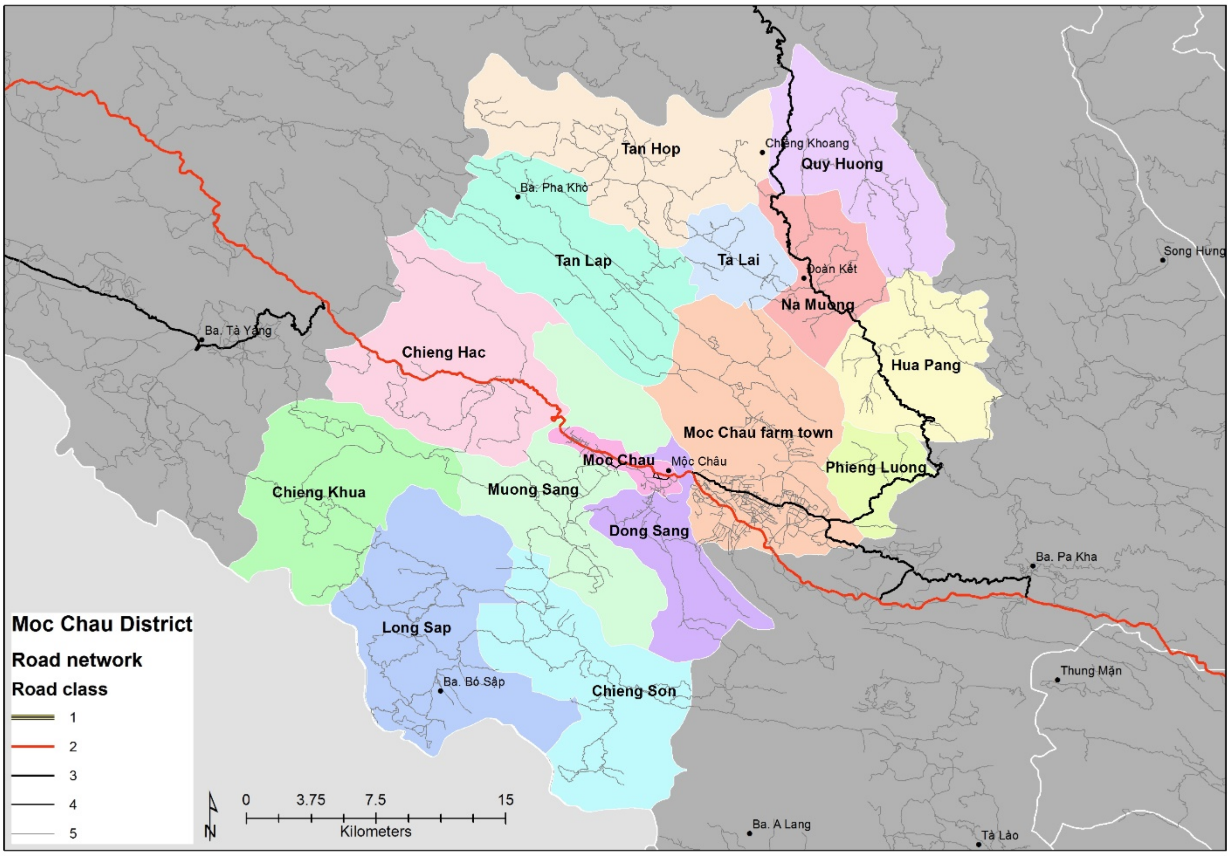

Figure 8.15 Communes and road network, Moc Chau District, Son La Province

The key datasets used in subsequent baseline and scenario modelling are listed below. Further information on these datasets, including source, attributes and processing undertaken within the project, is provided in Appendix 2: :

- District level agricultural production data (tonnes) for maize, cassava, sugarcane and coffee
- Commune level agricultural production data for maize, cassava, sugarcane and coffee as well as vegetables, Mai Son and Moc Chau districts
- Agro-enterprise data
- Import and export volume data and statistics
- Classification of cultivated agricultural land
- Human population, density and poverty data by district
- Road network
- Commercial Vehicle Tracking System (CVTS) data
- Truck operating cost data
- Product flow and transport maps of key commodity supply chains based on published reports, secondary sources and interviews with key informants
- Data as gathered from workshops/meetings in Son La Province with farmers and other supply chain actors

Baselines

TraNSIT baseline

Following collation and preparation of datasets (generally cleaning, gap-filling and geo-location, as Appendix 2:), baselines were generated in TraNSIT for each of the studied commodities.

The flow and transformation of products from farm to processing enterprises then further downstream for export, consumption or further processing was mapped for each of the studied agricultural crops (refer supply chain maps in Appendix 2:). This step documented the volumes (tonnes) of product moved between key nodes in the supply chain, the product form, how it was handled and the type and size of truck or vehicle (e.g., motorbikes) used. This information was used to inform the baseline model. Output least-cost routes for each origin – destination movement were amalgamated to create overall truck movements and costs per commodity and per supply chain 'leg' (eg. farmer to collector, collector to factory).

Focus commodities

Maize, cassava, and sugarcane were chosen as the main target crops for analysis across Son La Province, as they produce the largest tonnages of total farm output and transported volumes in the province (Figure 8.16). Coffee was also included due to its importance for income generation to local upland communities, even-though product area and volumes are considerably lower.

For the baseline (and subsequent scenario) analyses, district-level production data was used across the province, with higher-resolution commune-level production data being used across Moc Chau and Mai Son districts.

Mai Son District is a very important production and processing hub for sugarcane, maize, cassava, and coffee. Over 600,000 tonnes of agricultural commodities are produced and transported in this district, the highest by far compared to other districts in Son La (Figure 8.17).

In Moc Chau District, vegetables were also analysed. Since 2010, there has been a significant increase in production areas and volumes for vegetable and fruit crops in Moc Chau and some other districts such as Van Ho and Song Ma. These higher-value crops present opportunities for local farmers and communities to significantly increase their farm incomes. Being more perishable, vegetables and fruits also present new challenges for transport, logistics and market connectivity. As shown in Figure 8.16 and Figure 8.17, there are also significant and increasing volumes of longan, mango and plum being established, produced, and traded into local and export markets. Fruits were not included in our analyses; however, they could easily be incorporated in the future.

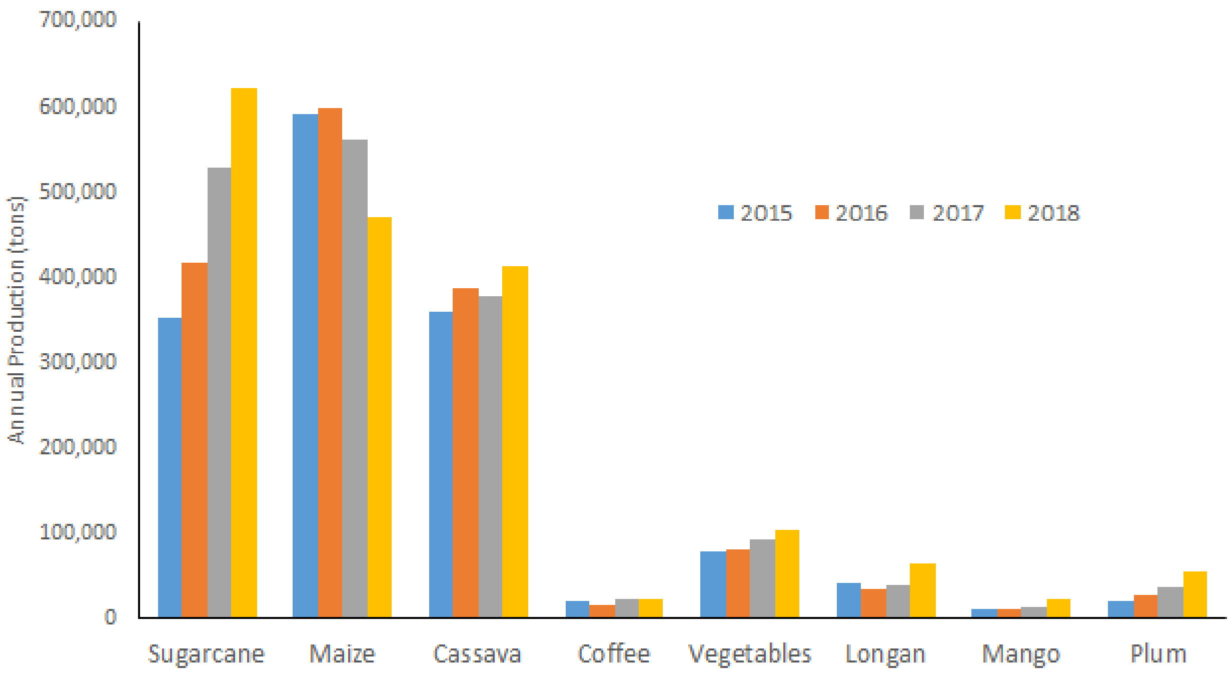

Figure 8.16 Annual production of baseline crops (and fruit) in Son La Province between 2015 and 2018. ***Source: 2019 Son La Provincial Statistics Yearbook***

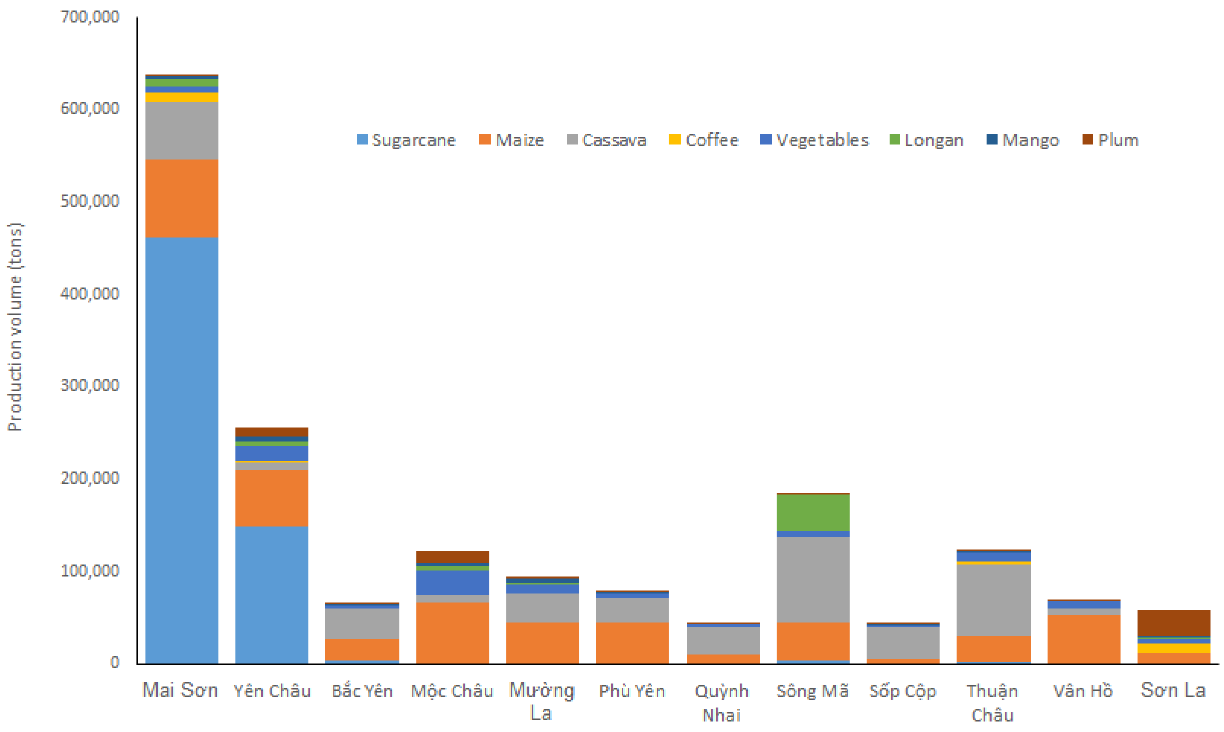

Figure 8.17 Total production volume (tonnes) of main baseline agricultural production crops (and fruits) in Son La Province by district in 2018. ***Source: Son La 2019 Statistics Yearbook***

The relationship between farm-level production (tonnes), unit crop price (VND/kg) and production value (US$ million) of cassava, maize, sugarcane, coffee, and vegetables is shown in Figure 8.18 for 2018. The total farm production value for maize was over US$94 million, compared to US$23 million for sugarcane and US$25 million for cassava. Production value for vegetables was over US$36 million. This provides an indicator of the relative economic importance of different crops to the province in relation to their production and transport volumes.

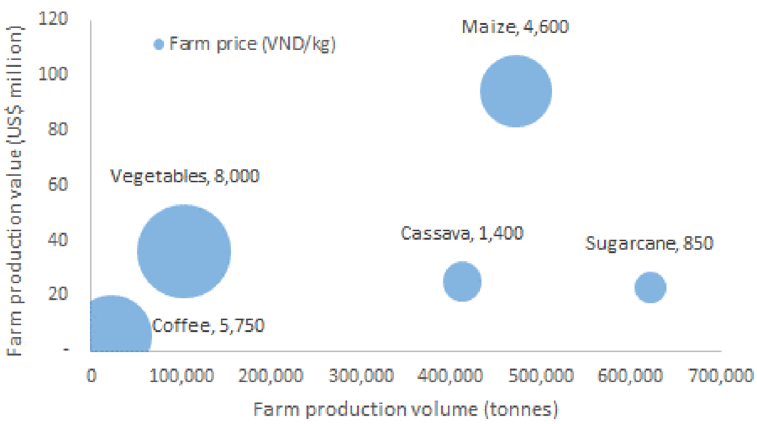

Figure 8.18. Total farm production, price, and value for selected crops in Son La, 2018.

Product and transport flows of main commodities

The volume, spatial arrangement, flow, and transformation of agricultural products between actors from farm to market directly impacts cost-efficiency of transport and chain competitiveness.

Cassava is often grown in remote, steeply sloping upland areas. It is also an important source of income for many poor households in Son La (Pham *et. al.* 2018). In 2018, over 400,000 tonnes of cassava were produced in Son La, with production volumes increasing since 2015 (Son La Statistical Year Book, 2019). Fresh roots are generally collected and transported from farms in 3-5-

tonne trucks to collection points, then aggregated and transported in 10-tonne trucks to factories in and around Mai Son District for processing into either starch at two starch factories, or into dried chips for livestock feed. Some cassava is collected or delivered from farms by motorbike in more difficult to access upland areas. Pham et. al. (2018) provides a detailed analysis of the cassava value chains in Son La.

From the factories, starch or dried chips are transported in very large 40-60-tonne trucks, mostly for export across land-ports into China. A small proportion is transported to livestock facilities around Hoa Binh and Hanoi. Fresh roots yield about 25% of dried starch, a 75% reduction in transport volumes following processing. The moisture content of cassava roots is reduced by drying from 70% to around 10% for dried chips.

Like cassava, most sugarcane and coffee produced in Son La is processed at mills and factories in Coi Noi commune, Mai Son District before being transported out of the province as processed products.

Over 625,000 tonnes of sugarcane were produced in Son La in 2018. This converts to around 60,000 tonnes of sugar transported following refining, assuming a 10% conversion rate. The Son La Sugar company operates the refining mill in Coi Noi and is responsible for coordinating transport of cane from contracted farmers during the harvesting period using their own 10-15 tonne trucks or contracted transport suppliers. Unlike coffee and maize, sugar needs to be transported relatively quickly after harvest for milling to ensure sugar levels are retained.

Son La produced over 450,000 tonnes of maize in 2018 (Son La Statistics Year Book 2019), although production has declined since 2015, mostly because of lower prices. Maize is collected and transported as cobs from farms by collectors in 3-5-tonne trucks, then to larger traders in larger 20-30-tonne trucks for drying, shelling, pesticide treatment and storage at drying facilities located along the main highway near Coi Noi, Mai Son District. From these facilities, almost 80% of dried maize grain is transported by large 40-50-tonne trucks to large animal feed mills (e.g. Thuan Phat, JAPHA, Minh Hieum and CP) located in Hoa Binh, around Hanoi and other nearby locations. Here, maize is processed with other ingredients into animal feed, for direct delivery or distribution to pig, poultry, beef and dairy cattle and aquaculture facilities.

More detailed descriptions of maize supply chains, key actors and product flows for Son La can be found in reports of Lancon *et al.* (2014) and Ammar *et al.* (2019). Vangeron et al. (2019) describe the production and cross-border trade of maize from Houaphanh (Laos) into Vietnam.

Some traders in Yen Chau District also source significant quantities of maize from districts in Houaphanh Province located across the border in Laos. In 2018-19, it was estimated that around 8,000-10,000 tonnes of maize were sourced and imported into Son La from Houaphanh by Vietnamese traders, then transported down to feed mills around Hanoi (Vangeron et al. 2019). Most of the maize enters Son La Province through two official border crossings. Cross-border inflows of maize from Laos are relatively small. These were not included in this project's baseline analyses but can easily be included in future TraNSIT simulations.

Higher transport costs in distant and difficult-to-access maize growing areas will directly reduce trader marketing margins and the farmgate prices offered to farmers. Like other crops, road and truck access to maize growing areas, particularly remote upland areas, are critical for linking maize farmers to markets via collectors and traders. Across the border in Laos, there is an established practice and process of Vietnamese traders negotiating with local commune leaders and Government staff and assisting construction of feeder roads into remote maize producing areas to facilitate access. Local farmers in return may provide labour for road construction and agree to supply traders either as part of a contract or informal supply agreement. These arrangements have been documented in some detail by Vagneron et al. (2015).

In 2018, 27,000 tonnes of vegetables were reportedly produced in Moc Chau according to official Government statistics data used for these TraNSIT analyses. However, this may be an underestimate. Recent estimates suggest that production in the 2019-2020 production season was likely to be in the order of 50,000 tonnes (Vu Thi Phoung Thanh *personal communication*). Regardless, vegetable production is very important economically to Moc Chau District. Farm-level production value alone in 2018 was over US$9 million. Vegetable growing provides over 7,000 smallholder farming families and 40 traders opportunities to significantly increase their incomes.

Prior to 2010, vegetable production in Moc Chau was limited to small quantities for within-district consumption. Since 2010, vegetable production in Moc Chau has expanded rapidly, driven by increasing consumer demand from traditional and modern retail markets in Hanoi and surrounding northern provinces (Sen 2017). Moc Chau has a distinct competitive advantage for vegetable production during the summer period compared to production areas in the Red River Delta (RRD) due to the cooler mountain climate and compared to Dalat due to the proximity to Hanoi and northern markets (only 200km and 4-5 hours travel distance).

White cabbage, French bean, white radish, winter melon, pumpkin and chayote fruit are currently the dominant crops produced by volume. However, there are increasing volumes of higher value fruit and leafy vegetables such as tomatoes, cucumber, lettuce and other leafy greens being produced. Over 90% of Moc Chau vegetable production occurs during the summer season (mid-April to mid-Nov). There is relatively little production and trader activity during the winter growing season (Nov-Apr) - the main production season for the RRD. Supplies from farmer groups to modern retailers in Hanoi and to local consumption markets are the main market channels in winter.

Analyses

Using the baseline outputs, a range of important questions by government planners and policy makers, large traders, and processing factories can be investigated. For Son La Province, questions we examined through this project as defined by the project team with stakeholder input included:

- Where and what are the main chokepoints or network constraints that impede the efficiency and effectiveness of procuring and transporting agricultural products from farm to factory and market?
- Which road segments, routes and locations are most heavily relied upon for transporting specific agricultural products?
- Which road segments and routes are over-utilised in terms of their total transported agricultural product volumes and truck densities compared to the capacity of the road?
- What is the cost-efficiency of procuring and transporting agricultural products for different routes and locations from farm to factory along the existing road network? Where are the most- and least-cost efficient routes and locations?

TraNSIT was used to simulate the transported volumes, vehicle usage (density) and transport costs associated with cassava, maize, sugarcane, and coffee at the district level in Son La (incorporating commune level data for Mai Son and Moc Chau districts). A commune level baseline for vegetables only was also produced for Moc Chau District.

Cassava

Figure 8.19 shows casava production by district throughout Son La and the simulated road usage (in 20 tonne truck-trailer equivalents) associated with transporting cassava from the farm via traders to processing facilities then to land ports on the Vietnam-China border for export. Figure 8.19 clearly shows the large tonnages of cassava that converge into processing facilities for chips at the old Son La city airport, and the FOCOCEV Joint Stock Company starch factory in Muong Bon, Mai Son District. It also shows the outbound transport of most of the province's starch and chips from processing facilities along the National Highway 6, via Hoa Binh and Hanoi, to the Tan Tanh border gate near Lang Son for export to China.

Figure 8.20 shows a more detailed picture of the road usage (trailer equivalents: high usage (dark pink) grading to low usage (light pink) of transported cassava for each road segment within Son La Province). Here minor road segments (thin lines) with very high levels of usage (dark pink) and high tonnages can easily be identified. For casava at least, these heavily or over-utilised road segments may be priority candidates for upgrading. This figure also clearly shows the very high densities of cassava truck transport that occurs on specific feeder and trunk roads in Mai Son, particularly into and out of Muong Bon where the largest starch factory is located.

Finally, Figure 8.21 demonstrates how TraNSIT was used to analyse casava production and road usage information at the finer commune level-scale in Mai Son and Moc Chau districts. Again, minor roads with very high transport usage in high cassava production communes, can be identified.

Future analyses with TraNSIT could evaluate the feasibility of alternative or optimal locations for positioning new processing factories, priority roads for upgrading, or location of collection platforms for aggregating and transporting product in larger volumes closer to production areas.

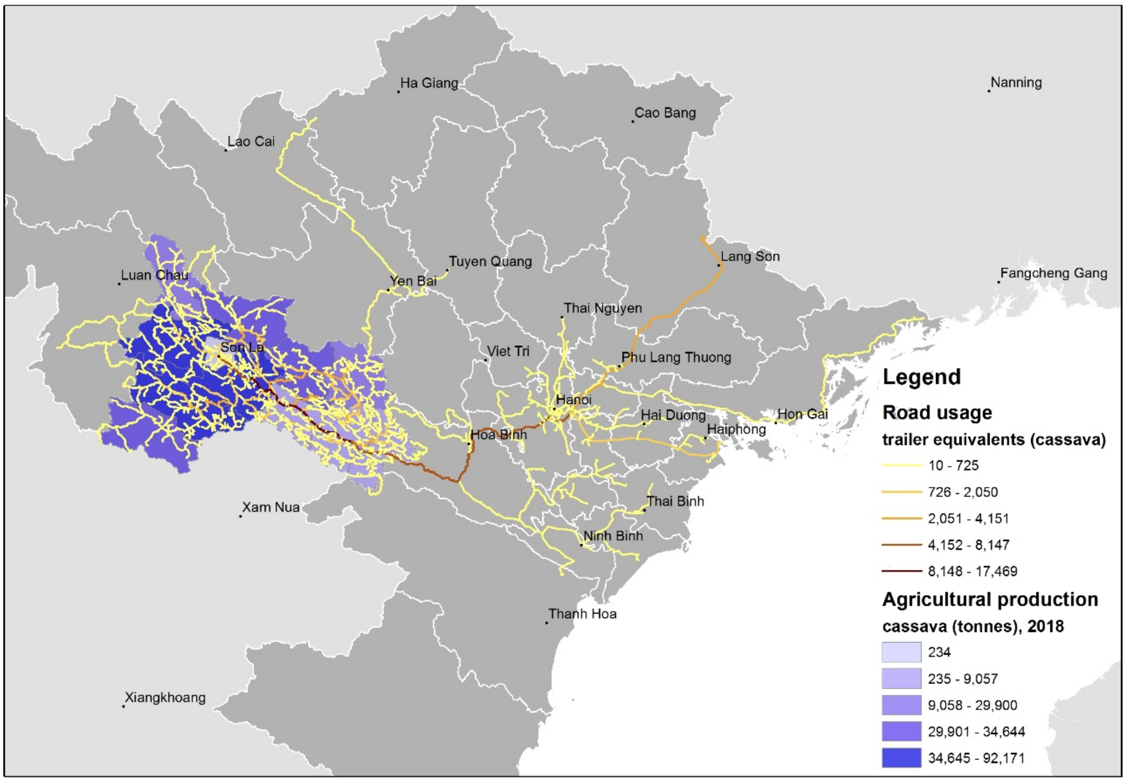

Figure 8.19 Cassava production and road usage for the cassava supply chain

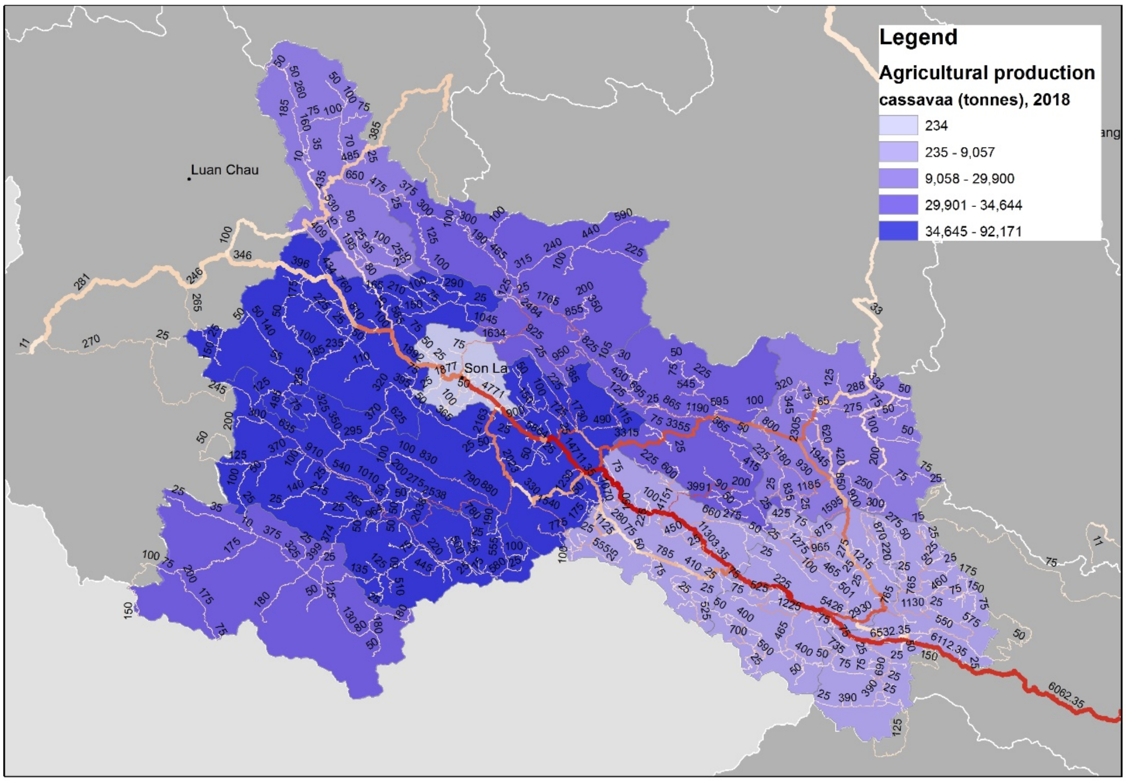

Figure 8.20 Cassava production and road usage for cassava supply chain, Son La Province

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

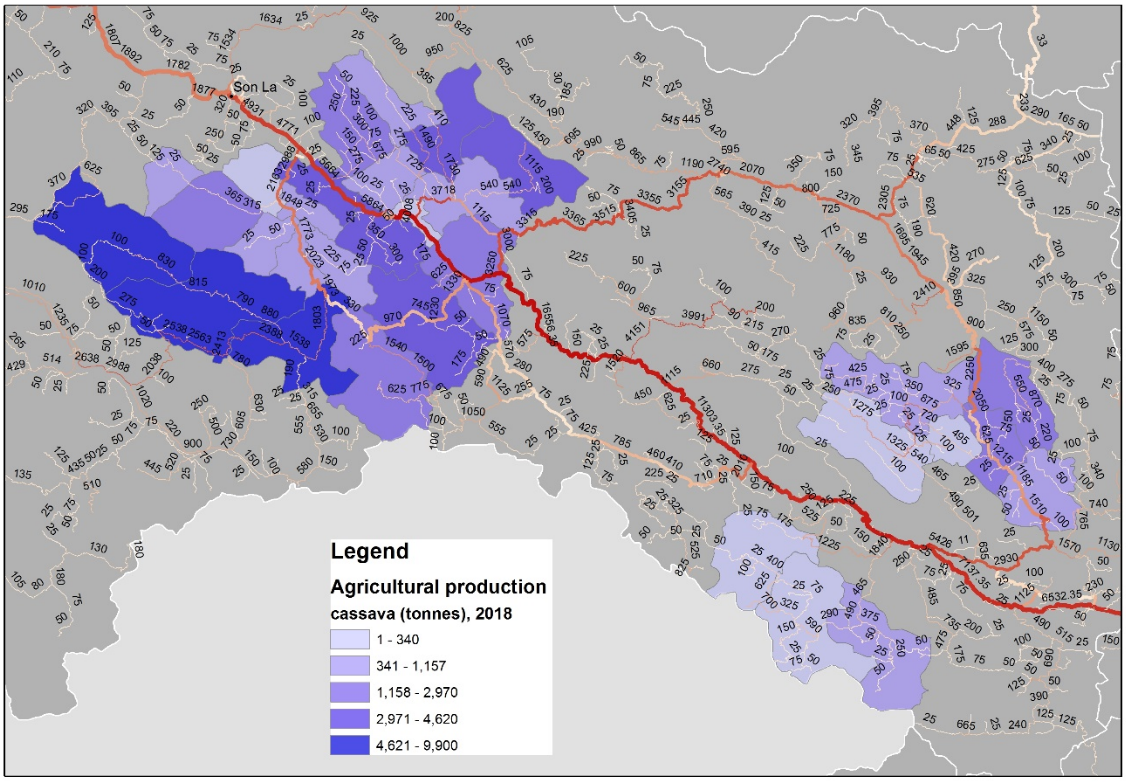

Figure 8.21 Cassava production and road usage for cassava supply chain, Mai Son and Moc Chau districts

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

Production and TraNSIT road usage simulations and outputs were also produced for maize, sugarcane and coffee. Map outputs for these can be found in Appendix 4: Additional model outputs - Vietnam. Some key observations from these analyses are summarised below.

Maize

For maize, the analysis shows production, trading and drying is heavily concentrated in Mai Son District, although production is more widely distributed across other districts compared to coffee and sugarcane. The TraNSIT simulation shows the very heavy road usage and reliance on the National Highway (QL6) to transport dried maize from trader-driers mainly in Mai Son District to animal feed millers in Hoa Binh and other locations around Hanoi. Like cassava, the analysis highlights which districts and communes in Son La have the highest levels of production and the minor roads and road segments with very heavy usage. These road segments can be easily identified from TraNSIT outputs to assist planners.

Strategic upgrades to the most heavily used minor feeder roads could improve the cost efficiency of maize transport and procurement by increasing average travel speeds, particularly if access of larger 15-20 tonne trucks is enabled. In some areas fresh ears, cobs or fresh grain is transported from farms to traders-dryers, which attracts higher transport costs. Therefore, in addition to road upgrades, options to increase the amount of maize that is dried, shelled, bulked or stored closer to main production areas may provide options to farmers and traders to reduce transport volumes and costs and add value (Lancon *et al*. 2014). There may also be opportunity to develop more innovative maize collection, haulage and transport vehicles, systems, and services for remote maize growing areas. Future TraNSIT analyses can help to evaluate the potential economic feasibility of these options for farmers, collectors, and traders.

Sugarcane

Sugarcane production is concentrated in Mai Son District, and districts immediately adjacent. TraNSIT analysis shows that road usage for transporting cane is highest and very concentrated around the sugar mill in Coi Noi, Mai Son District. Sugarcane produces very high biomass yields, with high moisture content and low farm-gate unit price (VND800-850/kg) even compared to cassava (VND1,400/kg) and maize (VND4,600/kg). Transport cost efficiency is therefore much lower compared to other crops. To be competitive, sugarcane is grown in areas close to the mill that are easily accessible by larger trucks. Refer to the section below - **Error! Reference source not found.** – which presents how TraNSIT was used to explore the transport distance-cost relationship in more detail for sugarcane.

Coffee

Production and transported tonnages for coffee are significantly lower than for maize, cassava and sugarcane. Compared to other crops, Arabica coffee production in Son La is concentrated in elevated areas (>1000m). Processing is mainly concentrated to four main companies in Son La and Mai Son (Phuc Sinh, Cat Que, Detech and Bich Thao). As a result, the main feeder and trunk roads around these processors experience the highest intensity of road usage for coffee transport.

Coffee processors transport over 95% of their products along the National Highway down to Hanoi and to Hai Phong for export as green bean. The proportion for other products, such as roasted bean and processed coffee, is very small (Le Huan personal communication).

Improving the density and quality of minor feeder roads to some remote upland growing areas that have strategic production potential would improve farm-trader linkages, transport competitiveness and encourage expansion of production. Improving road connectivity to services and markets would also benefit ethnic minorities who often populate these upland areas and are more affected by poverty.

Cassava, maize, sugar and coffee combined

TraNSIT was then used to analyse and map the aggregated production and road usage for the four main crop supply chains (cassava, maize, sugarcane, and coffee) in Son La Province. The intensity and extent of road usage and transport of crop products to destination markets is shown in Figure 8.22. This output demonstrates the importance of, and heavy reliance on the national highway (QL6) between Mai Son District and Hoa Binh as the main arterial link for transporting agricultural products towards end-market destinations. The farm-gate production value of these commodities alone is US$148 million.

Aggregated production and road usage for districts in Son La is presented in Figure 8.23 (for Son La Province) and Figure 8.24 (for Moc Chau and Mai Son districts). Again, the very high volumes of truck traffic and agricultural product transported into and out of Mai Son District, particularly around the Coi Noi trading and processing hub are a main feature. Highlighted in these figures are also minor road (class 1) segments with very high levels of modelled road usage, both in terms truck traffic and tonnages of transported agricultural products. These segments are likely freight bottlenecks in the road network. They could also be targets for examining upgrading options that could enhance all-weather access, use by larger trucks, or increased average speeds.

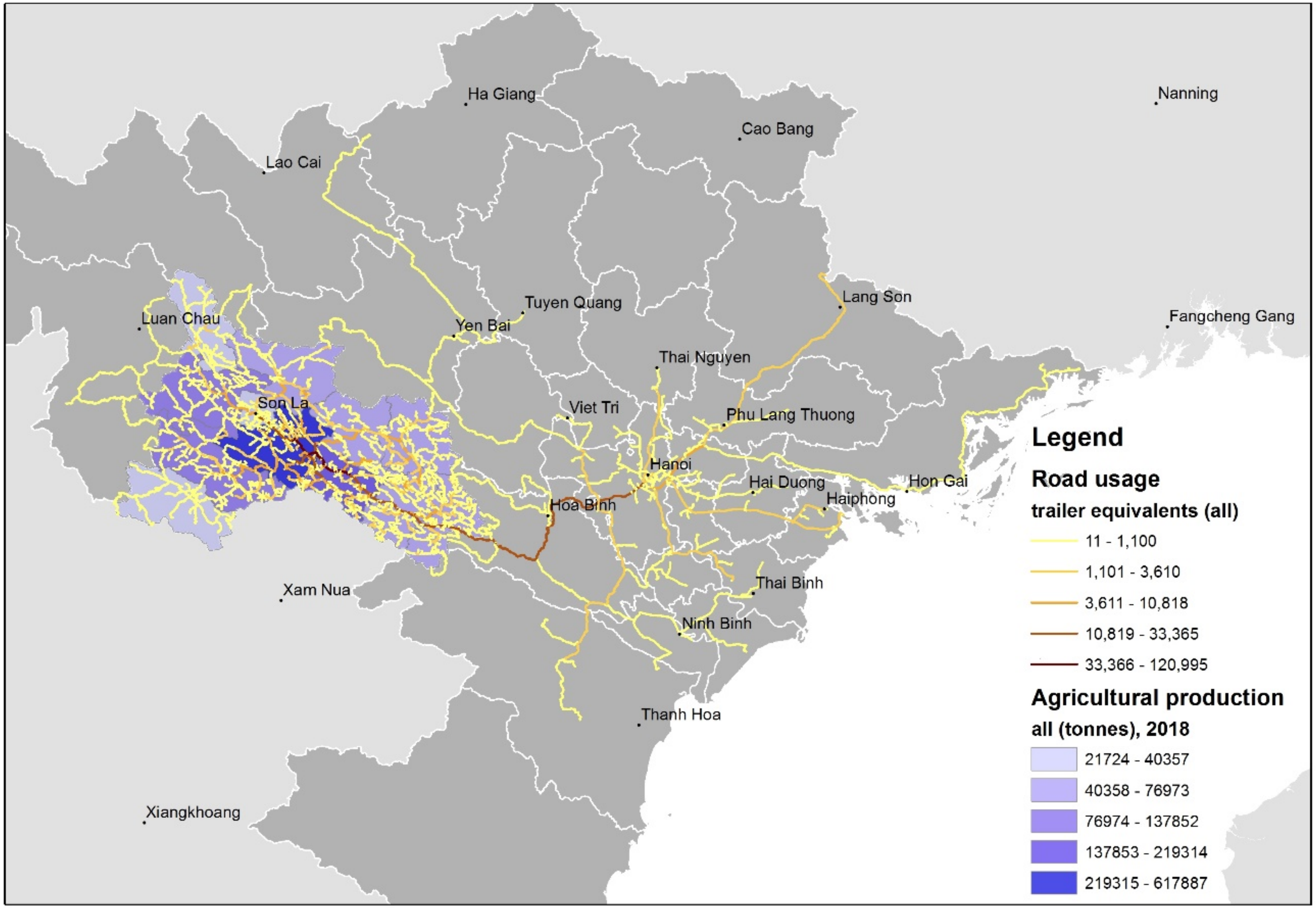

Figure 8.22 All production and road usage for all mapped supply chains

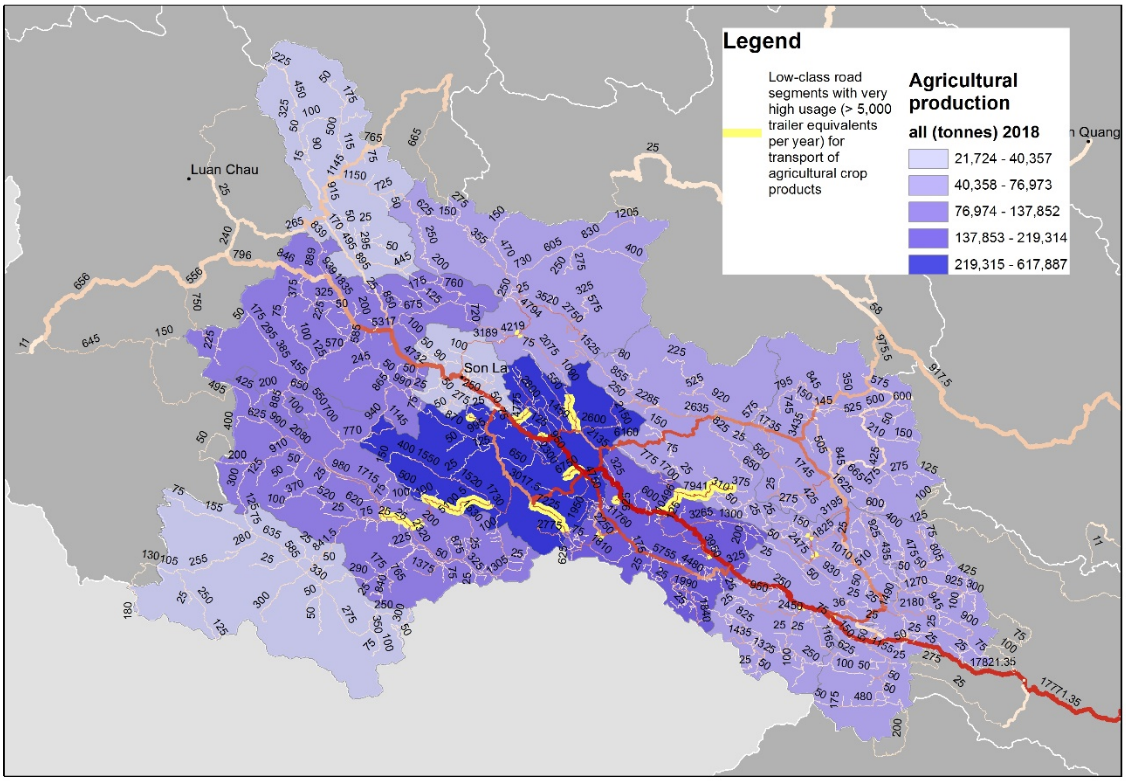

Figure 8.23 All production and road usage for all mapped supply chains, Son La Province

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

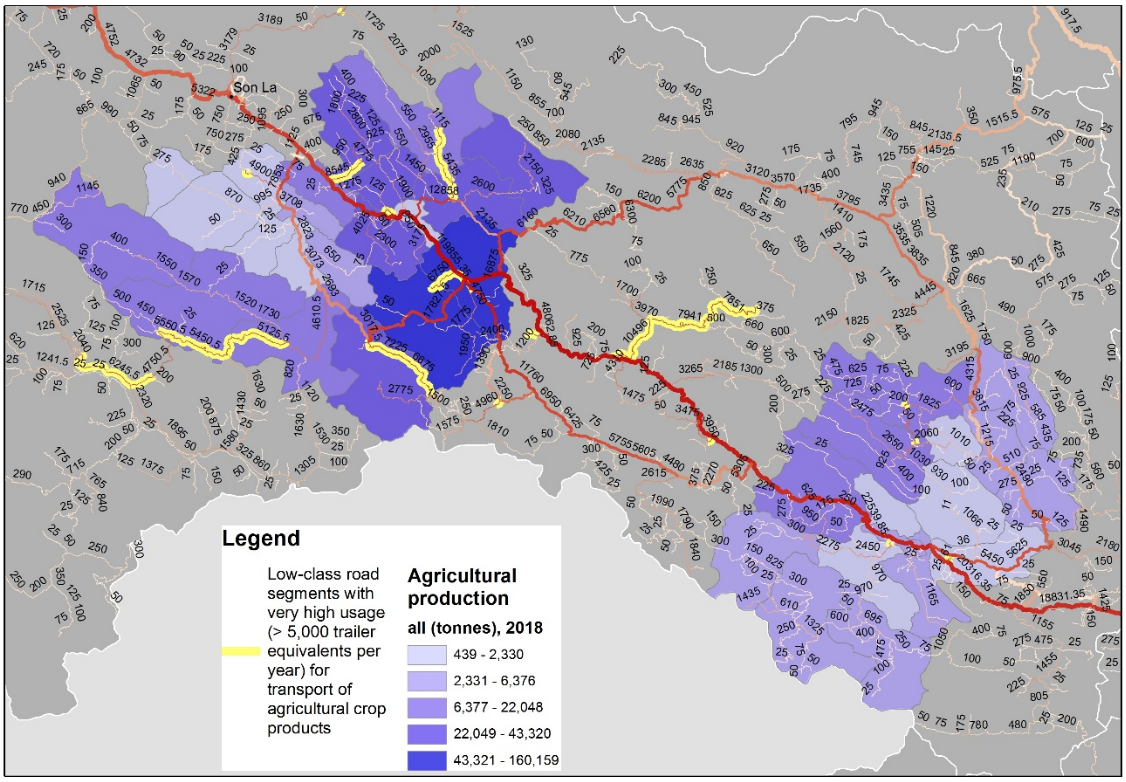

Figure 8.24 All production and road usage for all mapped supply chains, Mai Son and Moc Chau districts

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

The total annual transport costs for the four crop supply chains were estimated by TraNSIT to be US$17.65 million Table 8-7. Cassava and maize each accounted for 37-39% of the total transport costs. Sugar was 22% and coffee only 2%.

Table 8-7 Annual baseline costs by sector, commodity, and by commodity from the processing factory

MILLION VND	BASELINE (MILLION VND, (MILLION US$))
All	405,985 (17.65)
Sector	
Farm	251,298 (10.93)
Trader	106,444 (4.63)
Factory	48,242 (2.10)
Commodity	
Cassava	157,074 (6.83)
Coffee	7,168 (0.31)
Maize	151,590 (6.59)
Sugar	90,153 (3.92)
Costs by commodity from processing factory	
Cassava	24,732 (1.08)
Coffee	2,144 (0.09)
Maize	12,976 (0.56)
Sugar	8,391 (0.36)

The TraNSIT analysis indicated that 62% of transport costs were associated with trucking crop products between farms and traders, and 26% between traders and processing factories. Only 12% of transport costs were incurred post-processing. The higher upstream costs reflect the higher product transport costs per unit volume per kilometre, lower economies of scale and the higher volumes of unprocessed products. These high upstream transport costs are typical of “first-mile” challenges of procuring agricultural products from scattered, smallholder farming systems in remote and upland areas (Lancom *et al.* 2014).

Further downstream, post-processing transport costs were highest for cassava (6% of total transport cost) compared to other crops. This is likely a function of the large volumes of cassava starch and chips, and distance between processing facilities in Son La and the land port on the Vietnam-China border over 460 km away. Post processing transport costs for maize, sugarcane and coffee were less than 3% of the total.

The ratio of total farm-trader transport costs to farm production value provides a coarse measure of transport cost efficiency and varied considerably between crops (Figure 8.25). Transport costs for maize and coffee were <5% of the farm production value, much lower in relative terms compared to 11% for sugarcane and 16% for cassava. The implications of this for sugarcane are explored further in the section below - Transport distance-cost analysis to support industry planning and competitiveness.

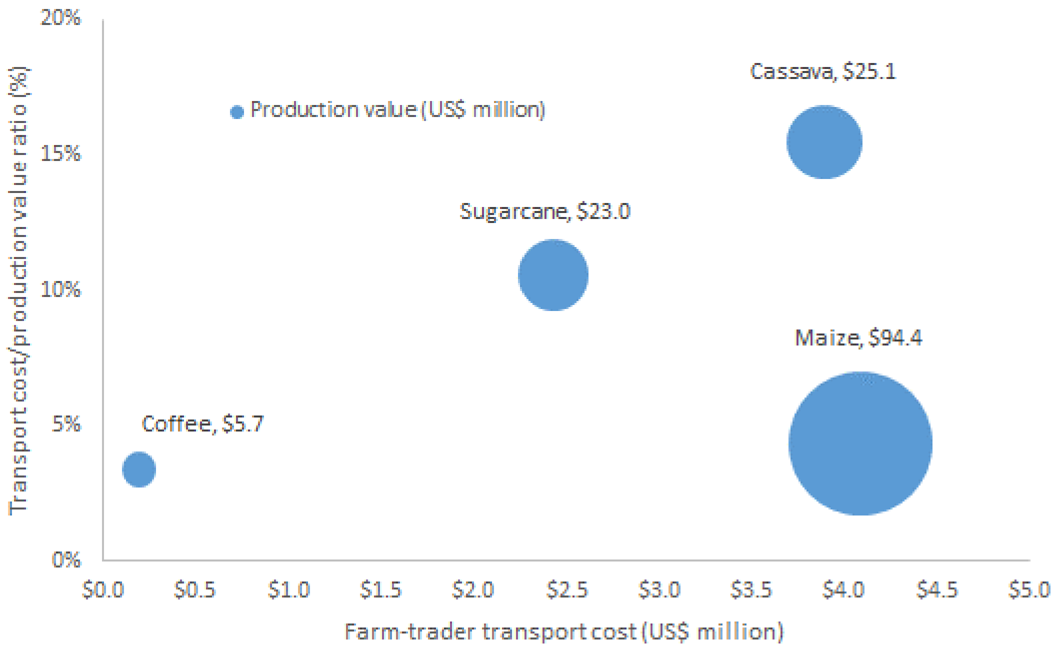

Figure 8.25 Relationship between farm-trader transport costs and farm production value (Ú$ million) for selected crops in Son La

A further example of how TraNSIT analysis can be used to assist planners objectively evaluate road segments for upgrading can be found in the section below - Assisting planners to identify road segments that would benefit most from upgrading.

Vegetables

Transport efficiency and market connectivity is particularly important for perishable agricultural products such as vegetables. In Moc Chau, vegetables are susceptible to post-harvest damage and quality loss, particularly where production is in upland areas far from good roads and only accessed via rough tracks or poor-quality minor roads. There is also an absence of cold storage and cold transport. Fresh produce from Moc Chau needs to be harvested, packed, collected and transported daily to wholesalers and retailers in Hanoi and surrounding provinces. Therefore, road connectivity, transport and logistics capability and services, and post-harvest handling are critical for competitive vegetable production and marketing.

In 2019, there was approximately 2,300ha of vegetable production in Moc Chau[2]. Figure 8.26 shows that rapidly increasing vegetable production in Moc Chau is focused in six communes: Tan Lap, Muong Sang, MC farm town, Phieng Luong, Dong Sang and Chieng Hac. Whilst these communes are highly suited to vegetable production, many more recent growing areas (e.g. Tan Lap commune) are more remote, and poor-quality roads make many growing areas difficult to access.

[2] *This has increased to over 3000ha in 2020.*

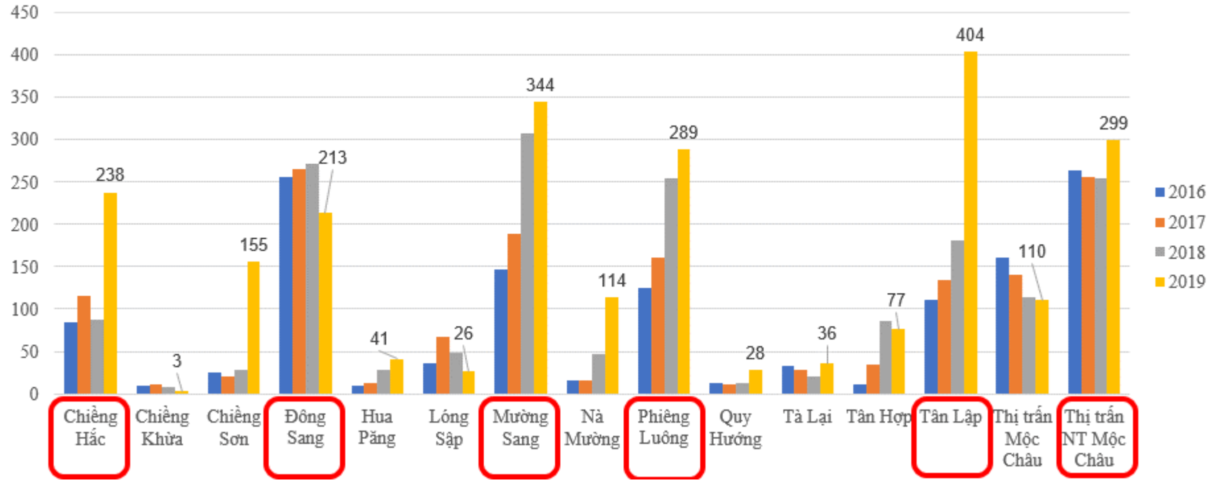

Figure 8.26. Changes in vegetable production planting areas in Moc Chau communes, 2016-2019.

Most of the 40 traders operating in Moc Chau trade over 5 tonnes per day during the April-November summer production season, often using small 1-2 tonne trucks to collect vegetables from farms. Remote and difficult to access fields, the poor condition of tracks and roads and small product volumes are the main reasons why small trucks are used. During a recent rapid value chain appraisal, traders operating in Tan Lap commune identified the need to urgently upgrade commune and district roads to improve access to growing areas, particularly for larger trucks (Vu Thi Phoung Thanh *personal communication*).

Following collection, vegetables are transported back to each trader's packing shed, normally located on district link roads, to be consolidated into loads for transport and delivery to a variety of wholesale and retail customers and locations. Around 70% of vegetables from Moc Chau District are transported to Hanoi and surrounding markets in small 3-5 tonne trucks. About 30% is transported in larger 15-20 tonne trucks to markets in Hanoi and other northern and central provinces.

Within this supply chain context there are some key questions about how best to improve road transport and connectivity to vegetable markets that are relevant to Government planners, traders and the increasing number of farmer groups and cooperatives:

- What upgrades to district and commune roads would most improve market connectivity, transport cost-efficiency and product quality? What are the benefits and opportunities from improving access of larger capacity 3-10 tonne trucks to remote growing areas? Which roads and areas are most important?
- What impact will the new Hoa Binh – Moc Chau expressway have on vegetable transport costs? How can traders and farmer groups adapt to get most benefit from the new improved road transport link?
- Can larger capacity 15-20 tonne trucks for delivering produce to Hanoi and other provinces reduce transport costs and maintain produce quality for traders and wholesalers? How?
- What are the benefits of establishing transport, logistics and marketing hubs for vegetables (and fruit) in Moc Chau? Would a larger centralised hub be more beneficial than multiple smaller facilities? Where would these facilities optimally be located?

Comprehensively addressing the questions above requires a detailed integrated TraNSIT and economic analysis. As a starting point in this report, TraNSIT was used to demonstrate how the intensity and extent of vegetable production, road usage and transport costs in Moc Chau District to market destinations in northern Vietnam could be analysed (Figure 8.27). This highlights the reliance on the national highway QL6 for transporting vegetables to Hoa Binh and onwards to Hanoi, and other northern provincial and central markets.

Vegetable production and density of road usage at the commune-level in Moc Chau is shown in Figure 8.28. Here, minor roads (class 5) with very high road usage and transport volume (greater than 500 trailer equivalents per year), including the link road to Tan Lap commune mentioned above, can be easily identified (and are highlighted). These are segments where road upgrades that enabled access by larger trucks, combined with innovations in product collection, handling and transport would provide significant financial and economic benefits. For example, in remote, difficult to access growing areas, farmers and traders tend to focus on vegetables which are easy to grow and transport such as chayote and cabbage. However, improved connectivity, truck access and road quality encourage traders and farmers to invest in higher-value vegetables such as tomato, cucumber and leafy greens which require more careful and efficient handling and transport.

The total annual transport cost for vegetables in Moc Chau was estimated to be over US$700,000, of which >90% was incurred by traders. This is not surprising, as demand increases, so does competition for produce, and to compete traders increasingly offer transportation services as well as harvesting, packing and input credit to commit farmers to supply arrangements.

Moc Chau vegetable growers and traders are likely to be major beneficiaries from the new Hoa Binh – Moc Chau expressway, expected to be completed in 2024. In the section below (see Table 8-9) TraNSIT analysis indicated the expressway could reduce transport distance, time, and cost between Moc Chau and Hanoi - a main market destination - by 13%, 52% and 29% respectively.

This creates an opportunity to explore what other upstream road and transport connectivity improvements could be integrated into the new expressway to provide added benefits. This could include targeted local road upgrades to improve connectivity and access to priority vegetable and fruit growing areas; improving product collection, aggregation, and transport services to growing areas; including the use of larger trucks; and exploring the feasibility of establishing local transport, logistics and cold store hubs. These are ideal scenarios and applications for TraNSIT.

It is also worth noting that vegetable traders and their destination wholesale and retail markets are much more geographically dispersed compared to maize, cassava, coffee and sugarcane supply chains. For these commodities, processing is mostly highly concentrated in one, two or a small number of locations, often within Son La. For vegetables however, this dispersion creates less transport and freight congestion around a centralised trading and processing facility. However, it may also reduce the opportunities to find economy of scale efficiencies.

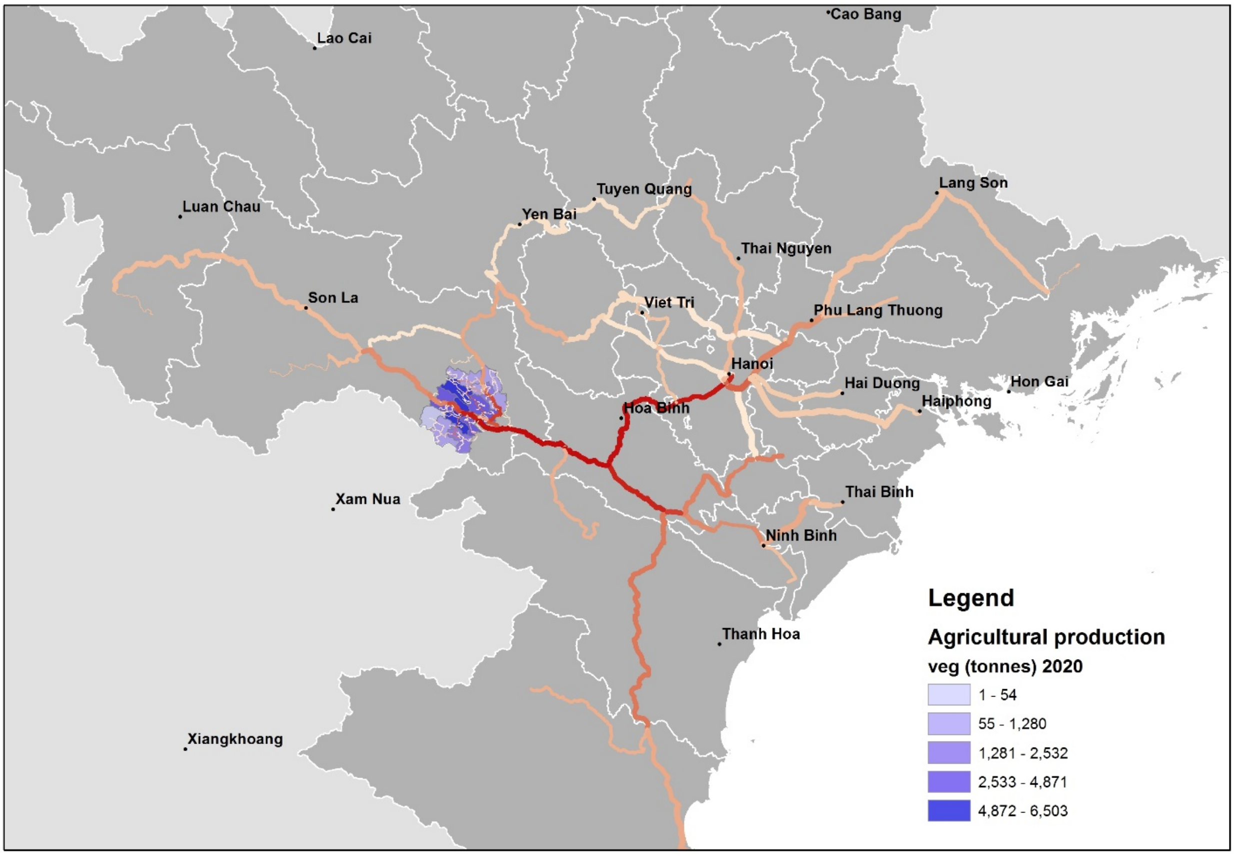

Figure 8.27 All production and road usage for vegetable supply chain, Northern Vietnam

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

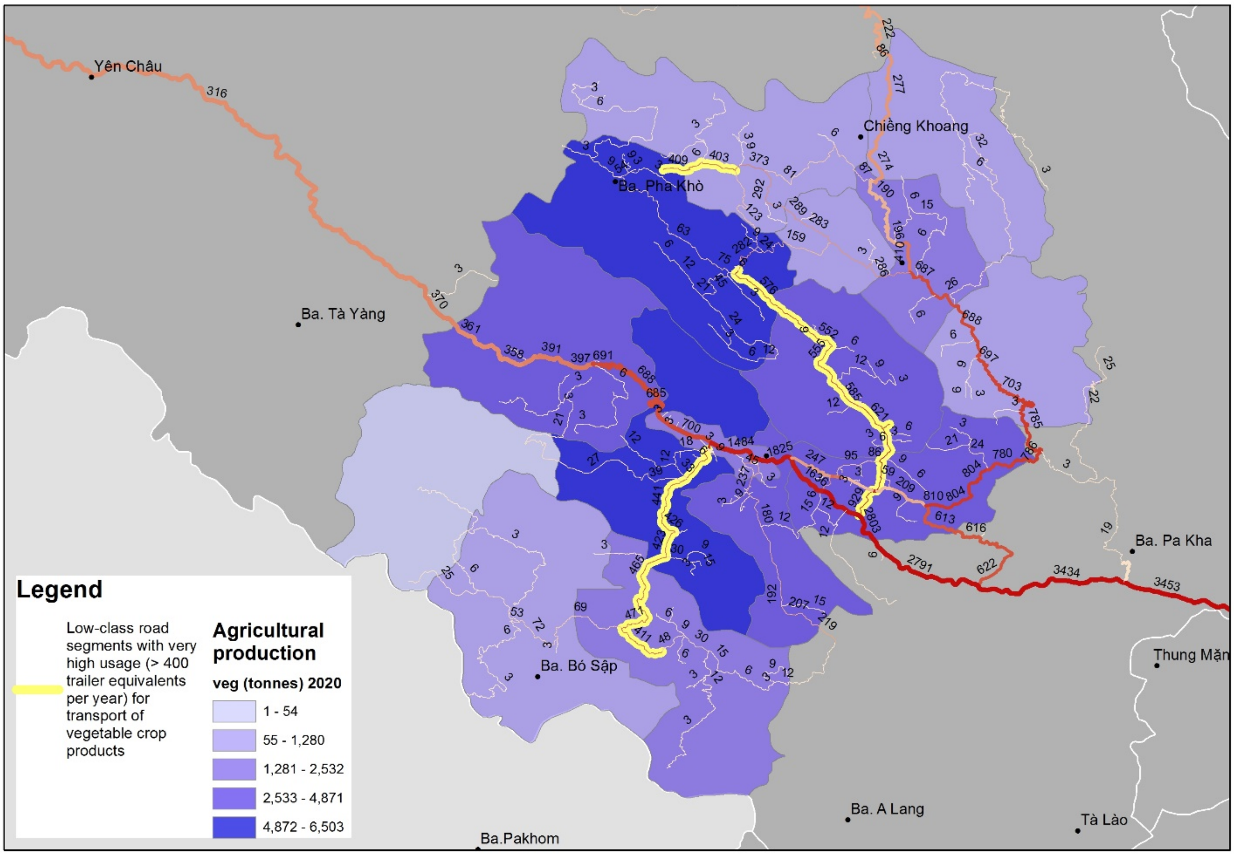

Figure 8.28 All production and road usage for vegetable supply chain, Moc Chau District

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

Scenarios

Scenario analysis allows examination of a changed system compared to the baseline. Scenarios in TraNSIT can examine changes to road usage and transport costs due for example to changes in production and enterprise volumes/locations/type, network conditions (e.g., road speed, new road, road surface, road cutting due to landslides/floods etc), logistics and transport mode. These analyses can determine more cost efficient or effective options to help plan and prioritise transport or supply chain infrastructure investments, thus supporting decision making, planning and policy.

With input from local collaborators, we determined the following list of scenarios for analysis:

- Impacts of proposed Hoa Binh to Moc Chau expressway on agricultural transport costs, travel times and competitiveness;
- Agricultural transport cost and connectivity benefits of proposed provincial road upgrades (Routes 3 (3. PR 104 QL6 (Chieng Sang)-Cho Long-Na Cai) and 10 (PR110 Mai Son-Na Bo-Muong Bu);
- Economic impact of road closures and disruptions from a landslide;
- Improving connectivity of disadvantaged remote communes with main economic corridors, markets and services;
- Identifying road segments where upgrading will produce greatest outcomes;
- Identifying where along the farm-market supply chain transport and procurement costs can be most efficiently reduced, how, and who will benefit from these changes.

To run each scenario model, the road network was updated with linework and attributes representing the scenario conditions (eg. new road with increased speed (expressway), increased speed for existing roads (route upgrades) and cut road segment (landslide)) and the output results compared to the baseline to examine differences.

Evaluating the impacts of the proposed Hoa Binh to Moc Chau expressway

In May 2019, the Prime Minister approved the Hoa Binh to Moc Chau expressway. The proposed investment for the new 85km route is expected to cost more than VND 22,000 billion. The expressway project is expected to improve road connectivity between the economic and political centres of Hanoi with Son La, and other north-western provinces. It will reduce the load on the current narrow, very steep, and mountainous stretch of National Highway 6 (QL6) and promote the economic and social development of these areas[3]. Construction is planned over four years, from 2020 to completion in 2024.

The prospect of the new expressway raises important questions for local provincial and district investors and planners, transport and logistics companies and agricultural product traders in Son La.

- What is the likely impact of the new expressway on agricultural freight and transport costs and times between Son La and Hanoi? Which districts stand to gain the most/least?
- How will the new expressway impact transport costs and market connectivity for different agricultural sectors such as maize, cassava, sugar cane, coffee, vegetables?
- Who will benefit the most from the expressway i.e., Son La farmers, traders, or processes?
- How will the expressway affect the use of other routes in the local network?

TraNSIT was used to explore these questions, particularly how the new proposed expressway would impact on agricultural transport flows and costs compared to the current National Highway 6 corridor. The expressway scenario was based on the original route proposed in 2018, which traverses Da Bac District in Hoa Binh Province (Figure 8.29). The scenario assumed the new expressway would allow average truck speeds of 100km/hr on the flats and 80km/hr in the hills. An updated route was proposed 2020[4] which could also be modelled with TraNSIT.

Figure 8.29 proposed route for new 85 km Hoa Binh – Moc Chau expressway expected to be completed in 2024. ***Source: VN Express***[1]

The current density of usage (baseline) for different road classes modelled in TranSIT is shown in Figure 8.30, with the approximate location of the proposed expressway. Density of usage is the intensity of truck use for the **combined tonnage** of cassava, sugar, maize, and coffee produced in and transported from Son La to various market destinations.

[3] Cao tốc Hòa Bình - Mộc Châu 22.000 tỷ đồng sẽ kết nối với Hà Nội - VnExpress

[4] Sẽ sớm triển khai dự án xây dựng cao tốc Hòa Bình – Mộc Châu (vietnamfinance.vn)

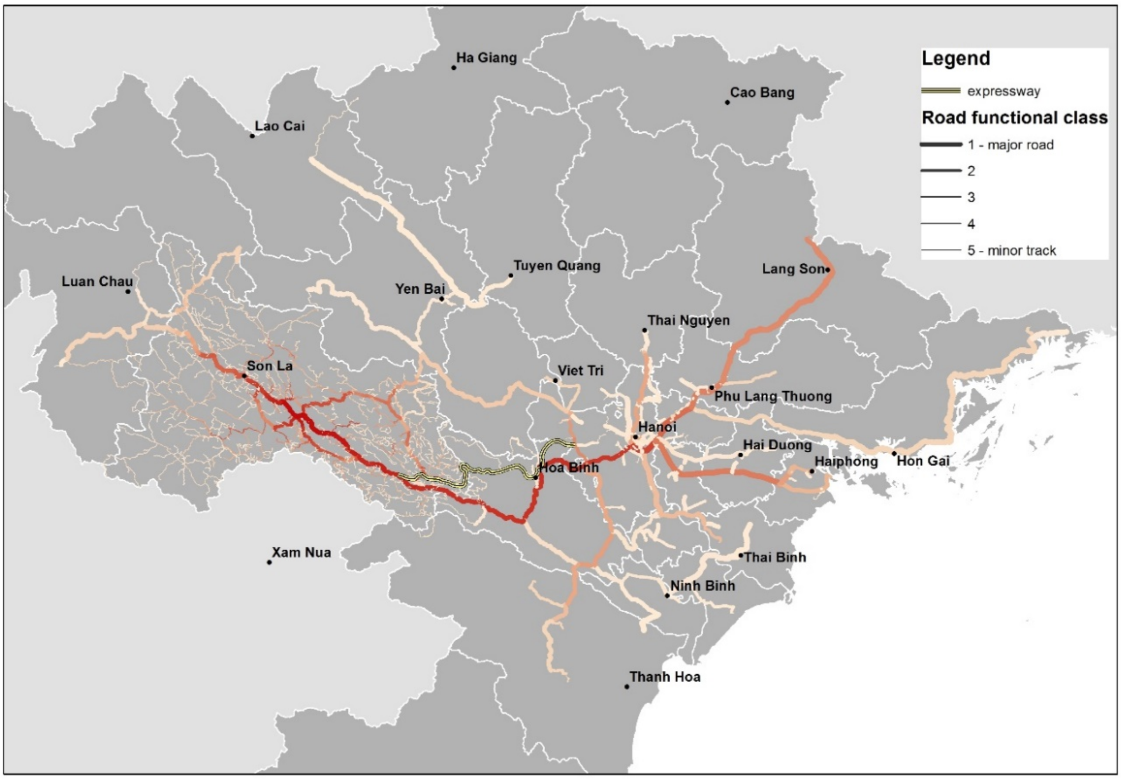

Figure 8.30 Current road usage for all mapped commodities (cassava, maize, sugar, coffee) with production in Son La Province, and approximate location of proposed Hoa Binh to Moc Chau expressway

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

The modelled change in road usage after the expressway is shown in Figure 8.31, with the before/after differences in usage highlighted in Figure 8.32 for the full supply chain extent, and Figure 8.33 for the region around the expressway. These figures show that under the modelled assumptions, up to 400,000 tonnes of road freight would be transferred from National Highway 6 to the new expressway between Moc Chau and Hoa Binh[5]. These Figures also show the expressway may result in only relatively small changes in freight and truck density along most feeder roads in the province. However, there is a small number of specific provincial and district feeder road segments that may carry significantly higher (bright red), or lower freight (bright green) densities under the new configuration, even though they are many kilometres from the start/end of the new expressway. For example, there are significant increases/decreases of freight density along road segments near the major processing centre of Coi Noi, Mai Son District. These changes could result in unexpected congestion or accelerated road deterioration along heavily utilised secondary feeder roads.

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[5] *Expressway scenarios did not include the additional cost of tolls, which may impact overall cost savings and route selection. It would be possible to examine the overall impact of toll cost scenarios in TraNSIT.*

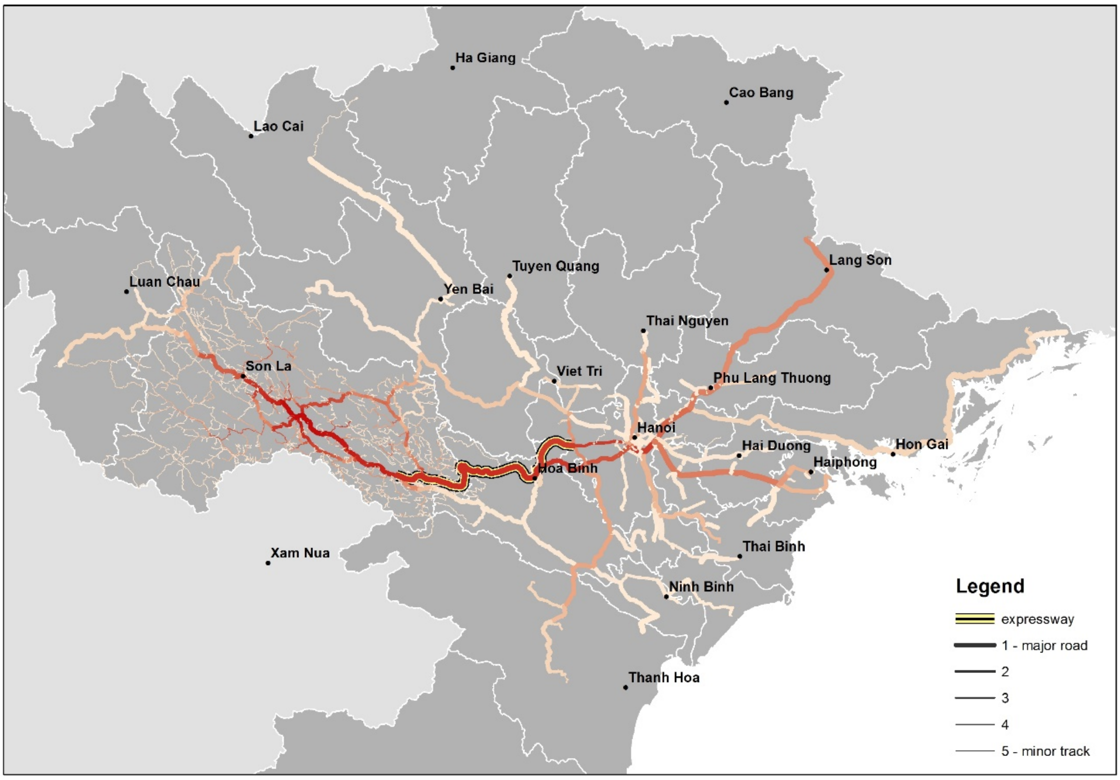

Figure 8.31 Modelled road usage for all mapped commodities (cassava, maize, sugar, coffee) with production in Son La Province after completion of Hoa Binh to Moc Chau expressway, and approximate location of proposed expressway

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

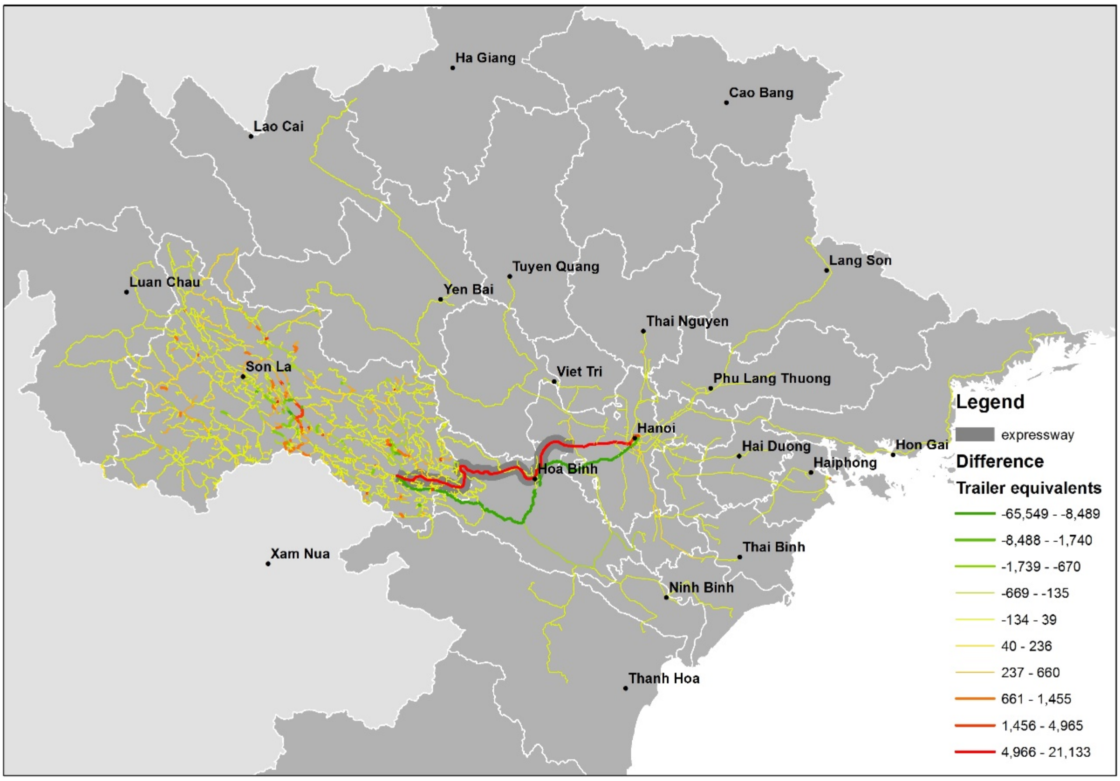

Figure 8.32 Difference in road usage (before/after) for all mapped commodities (cassava, maize, sugar, coffee) with production in Son La Province after completion of Hoa Binh to Moc Chau expressway

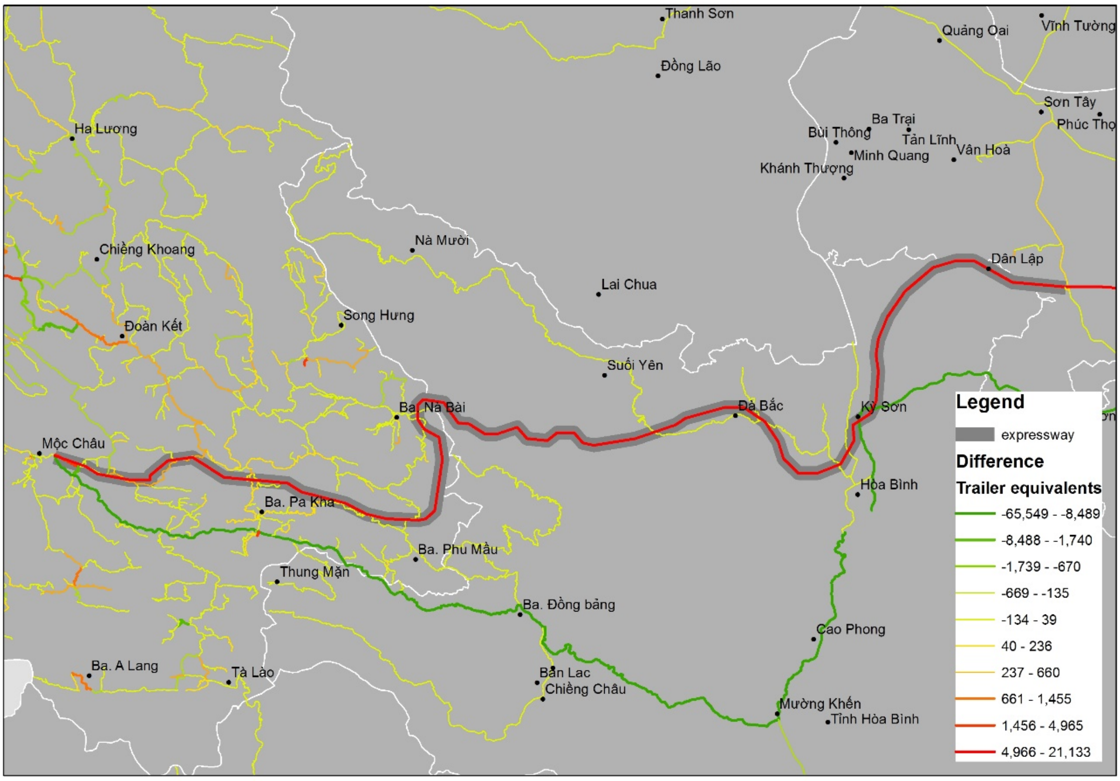

Figure 8.33 Difference in road usage (before/after) for all mapped commodities (cassava, maize, sugar, coffee) with production in Son La Province after completion of Hoa Binh to Moc Chau expressway (zoomed)

Total annual transport costs were also calculated for the baseline and expressway scenario (Table 8-8). Reduction in total transport cost between farms, traders, factories and destination market segments resulting from the expressway ranged between US$110,000-300,000. Traders may receive the greatest absolute transport cost reduction (US$300,000) from the expressway. However, processors would stand to benefit the most in relative terms, with a 10% reduction in transport costs from factories.

Table 8-8 Annual costs through use of the Hoa Binh to Moc Chau expressway compared to the baseline

MILLION VND	BASELINE (MILLION VND, (MILLION US$))	EXPRESSWAY (MILLION VND, (MILLION US$))	DIFFERENCE
All	405,985 (17.65)	391,730 (17.03)	4%
Sector			
Farm	251,298 (10.93)	248,902 (10.82)	1%
Trader	106,444 (4.63)	99,573 (4.33)	6%
Factory	48,242 (2.10)	43,255 (1.88)	10%
Commodity			
Cassava	157,074 (6.83)	152,040 (6.61)	37%
Coffee	7,168 (0.31)	6,937 (0.30)	3%
Maize	151,590 (6.59)	145,263 (6.32)	4%
Sugar	90,153 (3.92)	87,490 (3.80)	3%

MILLION VND	BASELINE (MILLION VND, (MILLION US$))	EXPRESSWAY (MILLION VND, (MILLION US$))	DIFFERENCE
Costs by commodity from processing factory			
Cassava	24,732 (1.08)	21,521 (0.94)	13%
Coffee	2,144 (0.09)	1,871 (0.08)	13%
Maize	12,976 (0.56)	13,021 (0.57)	10%
Sugar	8,391 (0.36)	6,842 (0.30)	18%

Of the four agricultural commodities, total transport costs associated with cassava and maize supply chains are reduced most in absolute terms (US$220,000-270,000). Although the relative transport cost savings are quite modest, ranging between 3-4% for all four crops.

The cost of transporting cassava starch and chips, processed sugar and coffee from the processing factories located around Son La city and Mai Son to destination markets will be reduced by around 13-18% by the new expressway. Cassava benefits the most in terms of absolute transport cost savings. For maize, there are no direct transport cost savings to animal feed mills which are all located in Hoa Binh downstream from the expressway. However, large maize traders or transport service providers who transport maize from Son La to the feed mills would benefit most.

The predicted reductions in per trip transport time, cost and length resulting from the Hoa Binh – Moc Chau expressway for different route sections are shown in Table 8-9[6]. The new expressway will save about 2½ hours of travel time for all sections, which translates to a total transport cost and distance saving of between 8-45% and US$56 – US$87, depending on the road section. Not surprisingly, transport and freight movements between Moc Chau and the Hoa Lac interchange will benefit most in terms of overall time, cost, and distance savings, as they are closest to the new and upgraded expressway sections.

Whilst not included in this scenario, it could be assumed the new expressway would also provide major transport cost savings for vegetables which are mainly grown in Moc Chau and Van Ho districts and transported by truck to markets in and around Hanoi.

Table 8-9 Change in per trip transport time, cost and length resulting from the Hoa Binh to Moc Chau expressway compared to the baseline, for different sections of the expressway

EXPRESSWAY SECTION	BASELINE			EXPRESSWAY			DIFERENCE (%)		
	Time (hrs)	**Cost (VND (US$))**	**Length (km)**	**Time (hrs)**	**Cost (VND (US$))**	**Length (km)**	**Time**	**Cost**	**Length**
Son La - Hoa Binh	7.89	8,166,610 (355.36)	307.44	5.17	6,661,260 (289.62)	282.33	65%	82%	92%
Moc Chau – Hoa Binh	3.20	3,307,170 (143.91)	124.42	1.32	2,003,300 (87.10)	100.39	41%	61%	81%
Moc Chau – Hoa Lac Interchange	4.20	4,511,450 (196.31)	167.29	1.52	2,497,570 (108.59)	127.68	36%	55%	76%
Moc Chau - Hanoi	5.13	5,283,330 (229.89)	194.36	2.39	3,739,340 (162.58)	168.81	47%	71%	87%

[6] *These are estimates for transporting cassava, maize, sugarcane, and coffee only, and do not account for other agricultural products, general freight or passenger transport.*

Evaluating and prioritising road upgrade investments

Evaluating and prioritising options for upgrading specific roads is a major planning and investment decision-making task for the Son La Provincial and District Governments. Funds for road improvements are limited. Concessional loans from multilateral development banks or bilateral donors, and budget appropriations from national, provincial or district governments are all utilised. The ability to analyse and compare the marginal changes in connectivity, transport costs and overall economic impact resulting from different road upgrading options could greatly support investment decision making.

Proposed investment upgrades for the road infrastructure throughout Son La Province are described in detail in the *General Planning of Road Transportation System of Son La Province in the period to 2020, and orientation to 2030* ("the Plan"). This comprehensive planning and strategy document provides the provincial and district Governments in Son La details about proposed route upgrades for national, provincial, district, commune (to village), specialised and urban roads throughout the province.

The Plan describes the overall target to increase the total number of routes in Son La from 1,870 to 2,890, and the total length of routes from 9,080 km to 11,674 km between 2010 and 2030). The Plan proposes to increase road density (km/km^2) from 0.64 to 0.82. The proposed upgrades have a total estimated road investment cost for the 2020-30 period equivalent to US$500 million.

The Plan includes detailed lists of specific proposed national and provincial route upgrades for 2010-2020 and 2020-2030 periods. The road type (code), route location (start-end communes), route distance (km), technical upgrade classification and estimated investment costs are all described for each route segment. The locations of the proposed provincial road upgrades (blue) documented in the Plan are presented below in Figure 8.34, overlayed by the road usage (trailer-equivalent density) for all mapped agricultural commodities.

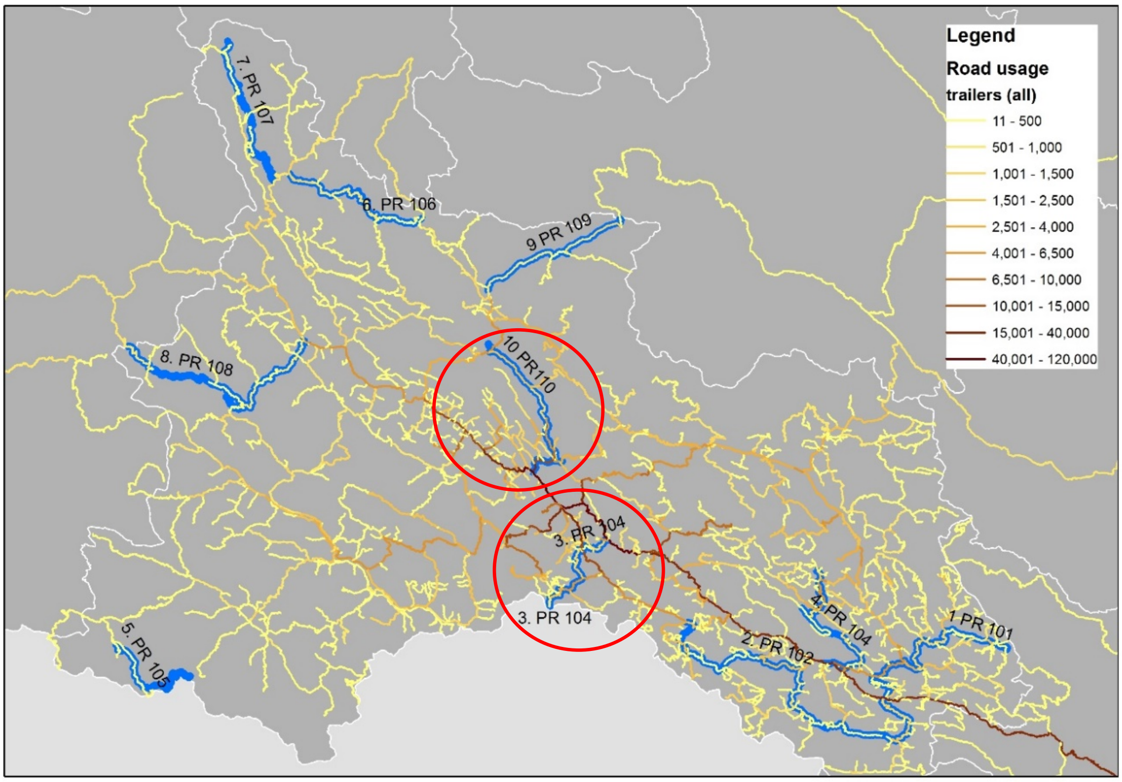

Figure 8.34 Provincial road upgrade locations (blue) with overlay of road usage for all mapped commodities (cassava, maize, coffee, sugar). The red circles indicate the location of the provincial road upgrades used in the scenario.

Some key questions Provincial and District Government planners may ask when considering where and how to allocate funds to local road upgrade investments include:

- What is the likely impact of different proposed route upgrades on connectivity to agricultural markets and product transport costs?
- Which agricultural sectors would most likely benefit from each route upgrade?
- What are the likely returns on investment and social benefits for different route upgrade options? Which upgrade routes are most important?

To demonstrate how TraNSIT could be used to assist road investment planning and decision making, the model was used to examine the impact of two provincial route upgrades described in the Son La Government's Plan. Details about the proposed upgrades to routes PR110 and PR104 extracted from Son La plan for provincial road system are shown in Table 8-10.

Table 8-10 Extract of information for upgrades to routes PR110 and P104 from Son La plan for provincial road system to 2020, with a target to 2030.

ROAD TYPE	BEGINNING - END	LENGTH (KM)	TECHNICAL LEVEL[7]			FUNDING (VND BILLION/US$)		
			Existing	2020	2030	2016-2020	2020-2030	Total
Provincial road PR110	Mai Son – Na Bo – Muong Bu	121.8	V-IV	IV	IV	19	450	468
Provincial road PR104	Moc Chau – Tan Lap – Tan Hop	48	GTNT	V	V-VI	100	34	134

Upgrades to PR110 and PR104 were selected as having the potential for most impact, given these road sections carry relatively large volumes of agricultural commodity traffic (for cassava, maize, coffee, and sugar), according to our modelling. To run these upgrade scenarios in TraNSIT, the road speed of the improved sections of PR110 and PR104 was assumed to increase from an average of 35km/hr to 60km/hr.

A comparison of transport costs between the baseline and the two road upgrade scenarios is shown in Table 8-11. It is important to note these are total transport costs for the four commodities across the whole Son La road network. There are three main points to note from this analysis.

Table 8-11 Changes in commodity transport costs across the whole road network relative to the baseline due to upgrading of provincial routes PR110 and PR104, Son La Province

	BASELINE (MILLION VND (MILLION USD))	PR 110 (MILLION VND (MILLION USD))	DIFFERENCE (%) (BASELINE/ROUTE 10)	PR 104 (MILLION VND (MILLION USD))	DIFFERENCE (%) (BASELINE/ROUTE 3)
All	405,985 (17.65)	400,403 (17.41)	1.4	403,133 (17.53)	0.7
Farm	251,298 (10.93)	246,500 (10.72)	1.9	249,388 (10.84)	0.8
Trader	106,444 (4.63)	105,794 (4.60)	0.6	105,166 (4.57)	1.2
Factory	48,243 (2.10)	48,109 (2.09)	0.3	47,905 (2.08)	0.7

First, as expected, the relative cost savings of an upgrade to a single route are very small compared to the transport costs across the whole network (in the order of 0.5-2.0%).

Second, based on the four commodities, the annual transport costs savings of the road segment upgrades are US$240,000 for PR110 compared to US$120,000 for PR104. However, the

[7] *Technical level (III, IV, V, VI) refers to the National standard for Rural Roads (specifications for design TCVN 4054:2005) which have a specific design for speed and vehicle load. Level III is the major road connecting provinces with the design speed 60km/hr, level IV (40 km/hr) and V (30 km/hr) are for districts, while level VI (or sometimes regarded as GTNT) is for communes, the design speed is only 20 km/hr. There is an updated standard in 2014 (TCVN 10380:2014), where the road classification changed to A, B, C, D.*

estimated investment cost to upgrade these roads extracted from the Son La Government plan is US$20.3 million for PR110 and US$5.8 million for PR104 (converted to US$ from Table 8-10). Together, this type of information can be used to assist local planners to evaluate more fully which option may produce the better return on investment. In this partial and simplistic example, even though PR110 results in greater transport savings, upgrading PR104 may provide a better return on invested funds. However, while a more rigorous modelling and economic analysis would be required to examine this more definitively, this demonstrates the ability of the model to quickly assess and compare the impacts of road upgrades objectively.

Third, most of the cost savings are generated for transport between the farm and trader (88% for PR110 and 75% for PR104). Benefits to transport from processing factories is understandably negligible. However, again, a more comprehensive TraNSIT and economic analysis would be required to fully understand these trade-offs.

These preliminary outputs demonstrate how strategic upgrades to important district and commune feeder roads can deliver direct upstream benefits to farmers and traders compared to major upgrades to main trunk roads. It should be kept in mind that road improvement investment for designated district and commune roads are generally administered under District and Commune Government budget plans.

Assessing the impact of extreme weather-related events (landslides) on road transport

Vietnam's extensive transport network is exposed to various hazards, including landslide, fluvial (river) flooding, cyclone, and flash flooding, all of which are increasing in intensity and frequency due to climate change (World Bank 2019).

Localised flash flooding and landslides are regular occurrences throughout Son La Province each year. Extreme rainfall and cyclone events are often associated with landslides that result in human casualties, destruction of rural homes and property, damage and prolonged closures to roads, and loss of agricultural land. These events are commonly reported in local and international media[8]. The impact of extreme weather events affecting Son La is compounded by the mountainous terrain, widespread deforestation, and annual cropping on steeply sloping lands (Kiel *et* al 2008). Some of the direct transport related economic costs caused by landslides include road damage and repairs, road congestion and delays, and the additional time and distance associated with finding alternative routes.

The Department of Transport in Son La collects detailed records of landslide locations that impact the road network. In consultation with Department staff, a location considered to be subjected to the most frequent and destructive landslides was selected for analysis from a list of 450 landslide locations recorded in 2018.

TraNSIT was used to explore the implications of road closure due to a landslide at this location on truck routing and transport costs for the four mapped agricultural commodities (cassava, maize, sugar, coffee). Road segments in the landslide area were modified so trucks could not pass, forcing an alternative route. The modelled vehicle densities and travel routes for all mapped commodities are shown in Figure 8.35 for the baseline, with Figure 8.36 showing the route and density impacts with the landslide in place. Figure 8.37 and Figure 8.38 show the before/after differences in vehicle movement, highlighting increasing (red) and decreasing (green) freight density.

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[8] *http://adinet.ahacentre.org/reports/view/1297; Ongoing rains pose risks of flooding and landslides in the north - News VietNamNet; Vietnam – At Least 12 Killed in Flash Floods and Landslides in North – FloodList Child killed due to landslide in Son La – VietNam Breaking News*

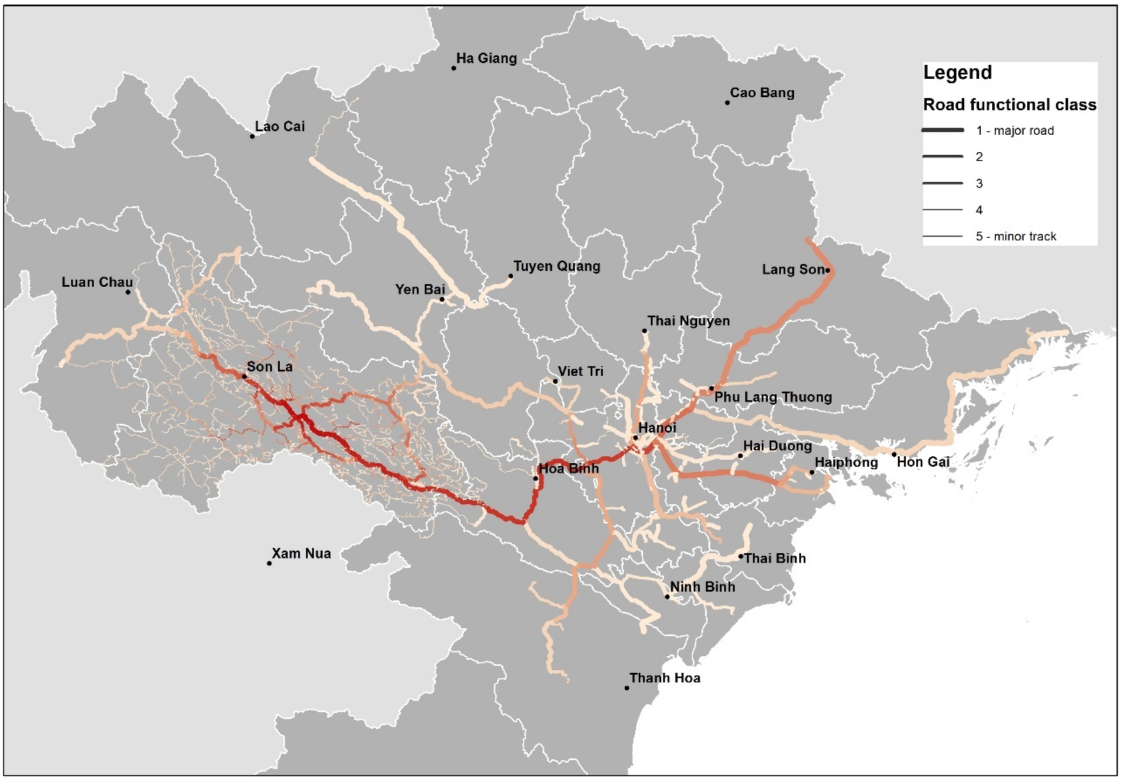


Figure 8.35 Current road usage for all mapped commodities (cassava, maize, sugar, coffee) with production in Son La Province

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

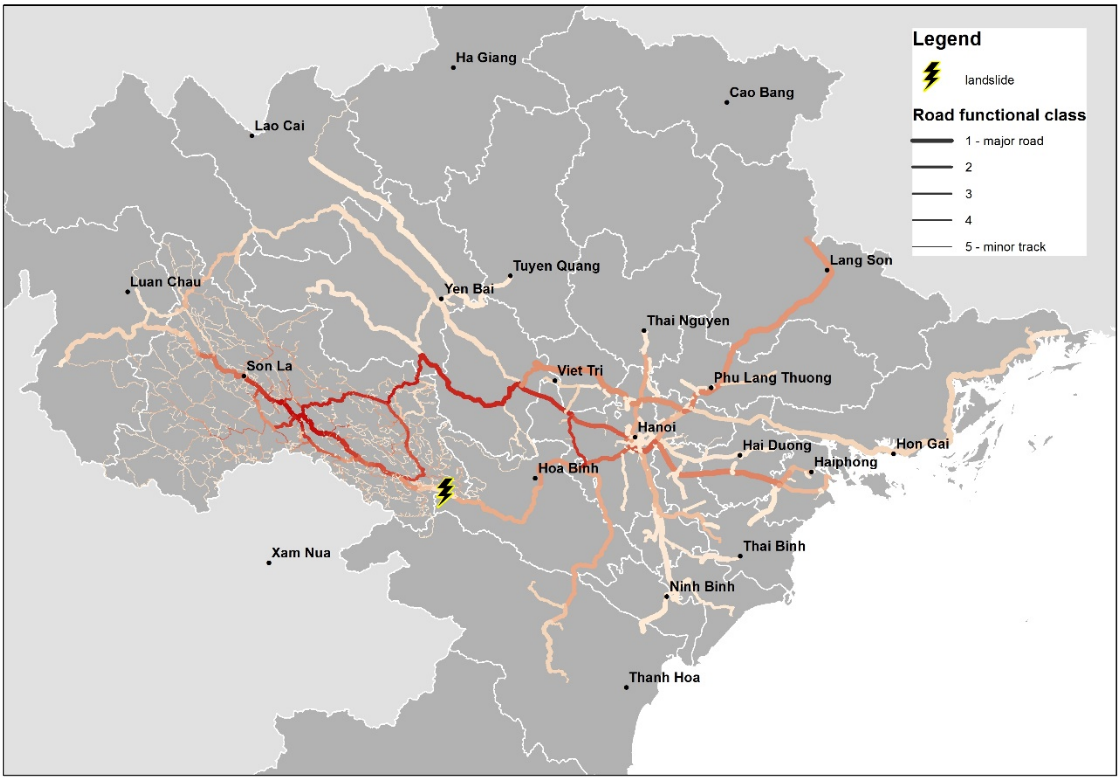


Figure 8.36 Proposed road usage for all mapped commodities (cassava, maize, sugar, coffee) with production in Son La Province, after blockage of main highway by landslide

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

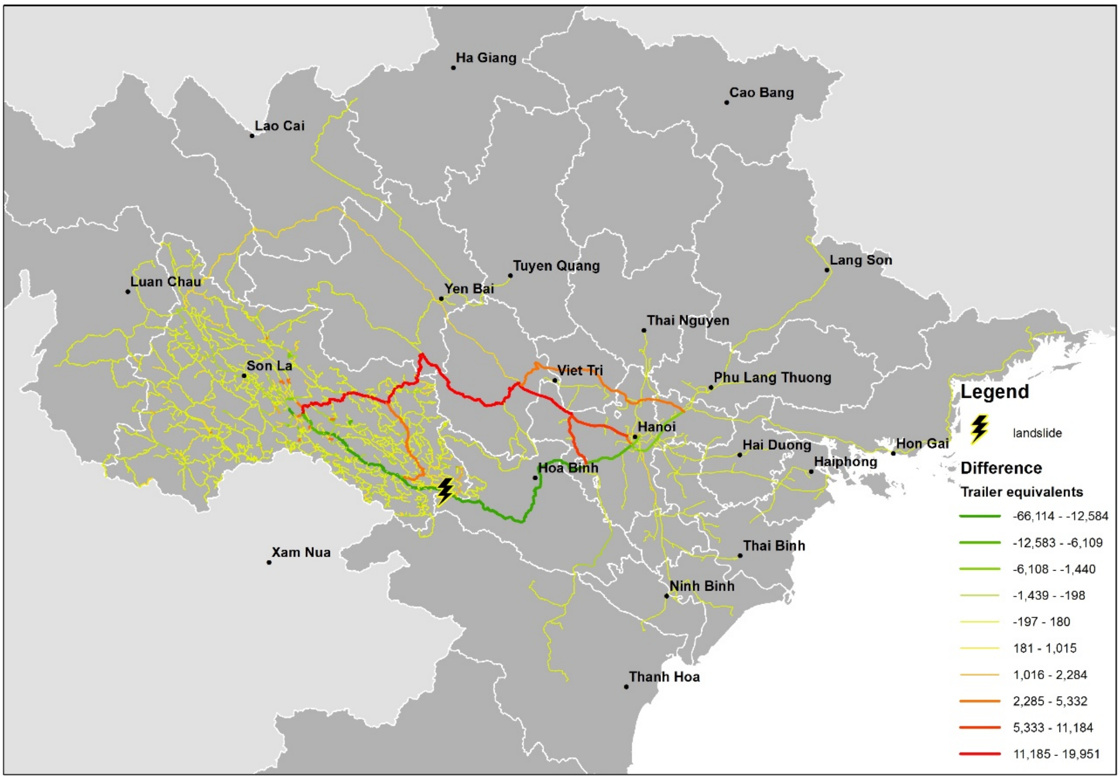


Figure 8.37 Difference in road usage (before/after) for all mapped commodities (cassava, maize, sugar, coffee) with production in Son La Province, for landslide scenario

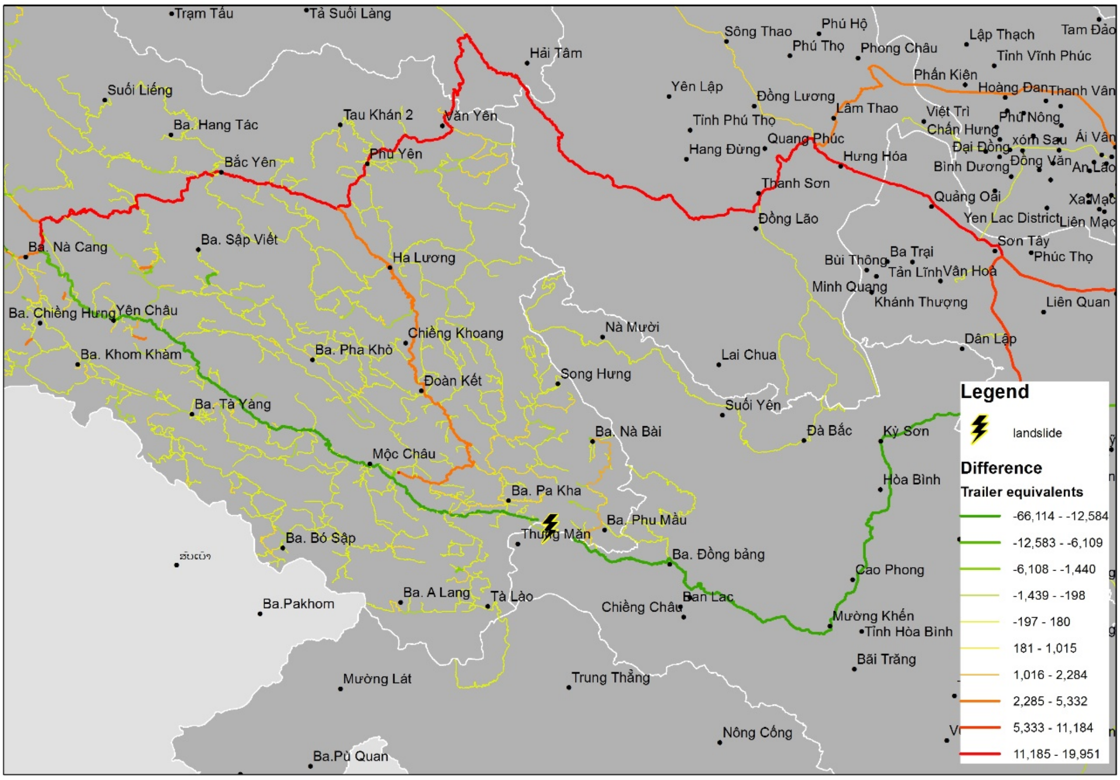


Figure 8.38 Difference in road usage (before/after) for all mapped commodities (cassava, maize, sugar, coffee) with production in Son La Province, for landslide scenario (zoomed)

The simulated impact of the road closure caused by the landslide results in an annualised US$870,000 (daily US$2,383) increase in commodity transport costs, due to re-routing throughout the network (Table 8-12).

In this scenario, 63% of the total increased costs were associated with transport from traders to factories, whilst 36% occurred from factory to destination markets. There was little impact on transport costs from farm to traders.

In this example, TraNSIT was used to explore the impact of only one landslide location on transport costs for four important agricultural products. A more comprehensive analysis could better account for total economic costs by including other agricultural and non-agricultural products, as well as passenger transport. It could also compare impacts for multiple sites with landslide risk and severity.

Table 8-12 Annualised costs across the whole road network due to landslide to the baseline, Son La Province

	BASELINE (MILLION VND (MILLION USD))	LANDSLIDE (MILLION VND (MILLION USD))	DIFFERENCE
All	405,985 (17.65)	425,966 (18.52)	105%
	Costs by sector		
Farm	251,298 (10.93)	251,387 (10.93)	100%
Trader	106,444 (4.63)	119,232 (5.18)	112%
Factory	48,243 (2.10)	55,347 (2.41)	115%

Assisting planners to identify road segments that would benefit most from upgrading.

TraNSIT was used to identify road segments (>500m length) from across the Son La road network with the highest per unit transport costs (VND/tonne/km) and highest usage (20 tonne trailer equivalents per year) for the four mapped commodities. For government planners, these roads may be priority candidates for upgrading as reducing transport costs could provide major economic benefits across the network.

Road segment transport costs and usage estimates as derived from TraNSIT were plotted in a scatterplot (Figure 8.39). Indicative boundaries (green lines) were added to classify road segment data according to arbitary regions of high-low transport cost and use. The cluster of road segments with lower transport costs (i.e., distributed along the x axis and <VND500/tonne/km) is associated mainly with use of larger 20 tonne trucks.

For planners, road segments located in the high-use and high-cost region (i.e., above and to the right of the green lines) may be priorities for upgrading. The locations of these road segments are highlighted in Figure 8.40. As indicated in previous analyses, many of these are very heavily used minor roads feeding into the trading and processing hubs in Mai Son District.

This approach could also be used to identify priority roads for upgrading for each crop supply chain, hence optimising decision making and focussing attention of upgrade to most effect.

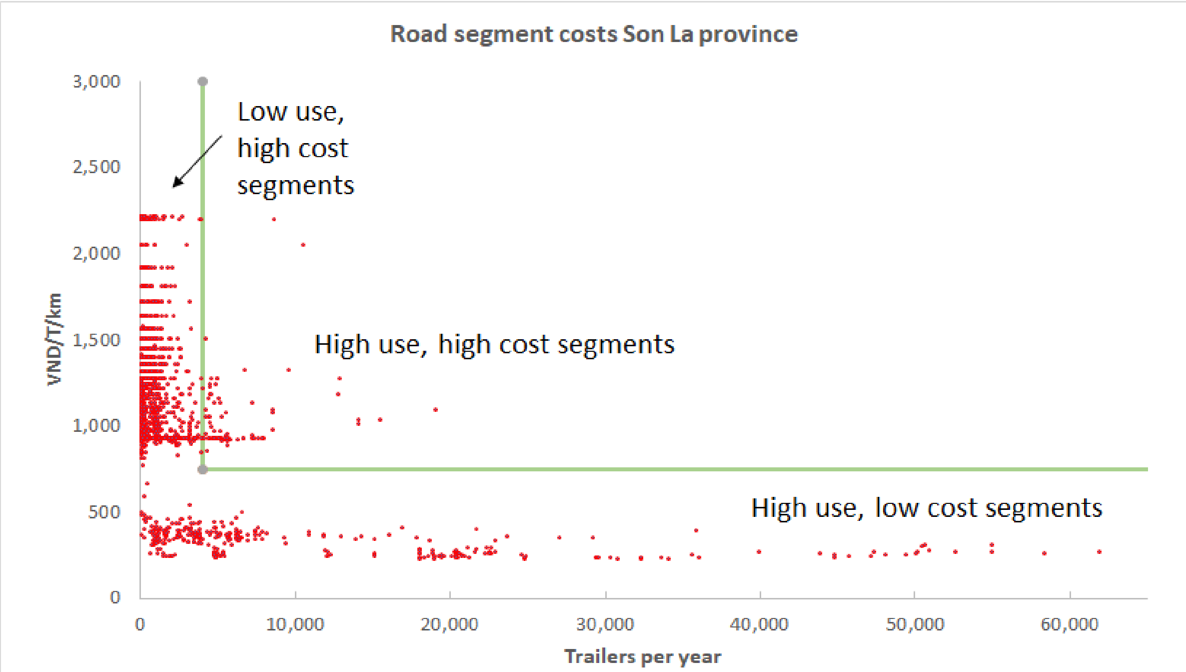


Figure 8.39. Scatterplot of transport cost (VND/tonne/km) and usage (20 tonne trailer equivalents per year) for individual road segments (>500m length) for target crops (cassava, maize, sugarcane and coffee) in Son La

Plot shows segments located within a matrix of high-low cost and use boundaries

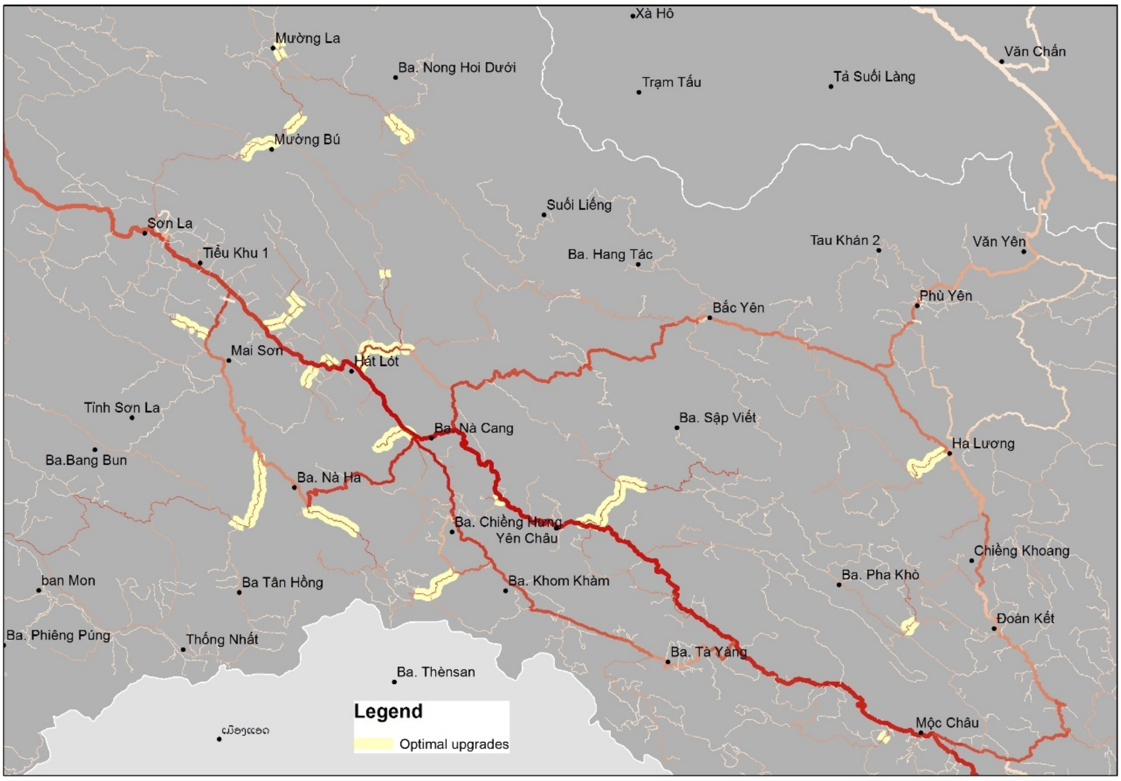


Figure 8.40 Suggested focus road segments for upgrade based on cost of travel (for cassava/maize/sugar/coffee combined) across road segments in Son La Province

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

Transport distance-cost analysis to support industry planning and competitiveness

An isochrone analysis was used to calculate transport cost of sugarcane from every point along the road network in Son La Province to the sugar mill (Figure 8.41). The transport cost efficiency of sugarcane is much lower than other crops such as maize and coffee (see Figure 8.25) due to high production and transport biomass, and lower unit product value. Unlike maize, sugarcane cannot be stored and must be transported for processing immediately after harvest.

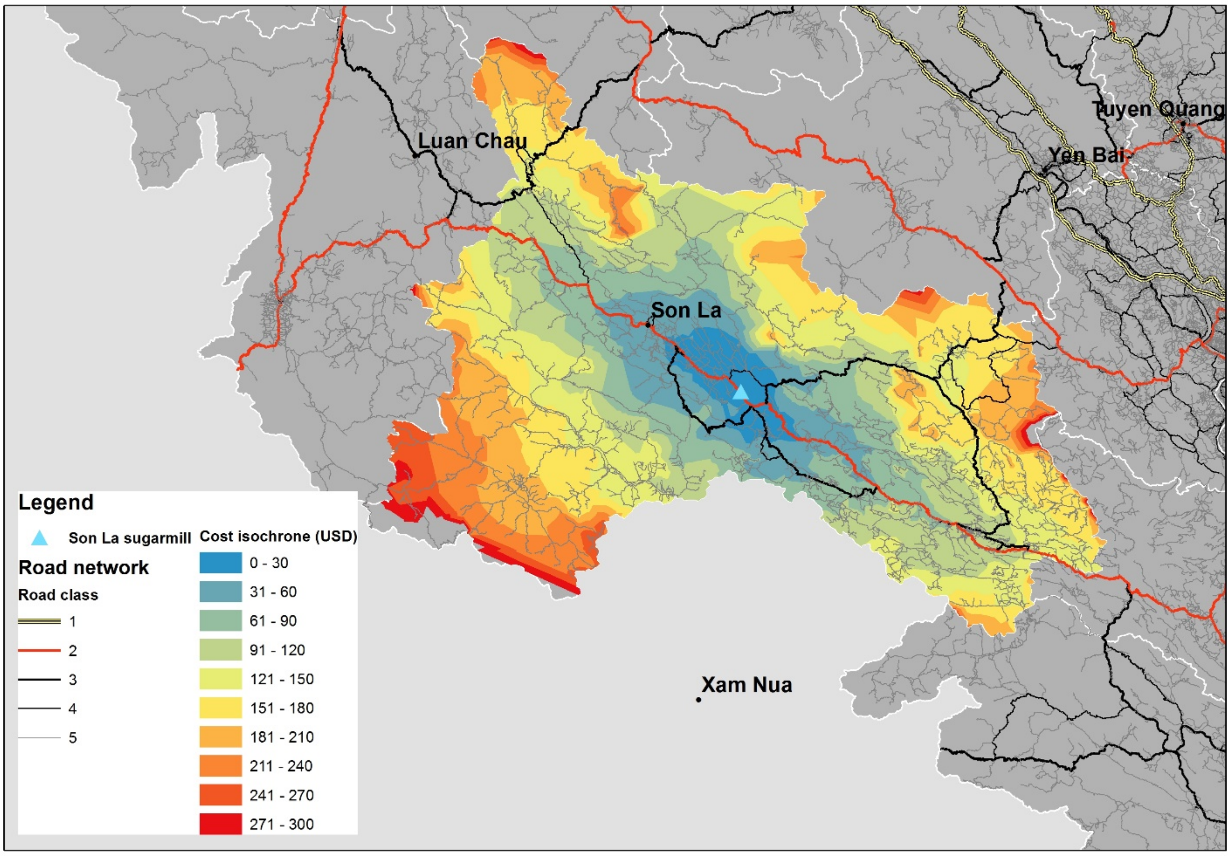


Figure 8.41 Cost of transport to sugar mill across Son La Province

Unlike other supply chains, the Son La Sugar Company owns and operates the sugar mill and uses their own trucks or contract transport service providers to collect and haul cane from contract farmers. Around 4,500 tonnes of cane is delivered to the mill each day between December and May each year. This is equivalent to around 300 trucks per day.

Therefore, to be competitive and keep transport costs to a minimum, sugarcane growing areas tend to be clustered close to the processing mill, and ideally adjacent to roads accessible to larger trucks (e.g.,10-15 tonne) that enable more efficient bulking, handling, and transport systems.

However, an issue identified by the mill procurement manager is that sugarcane areas closer to the factory have in recent years been displaced with higher-value fruit crops. Cane is now being grown in areas that are further away from the mill and are more difficult to access with large trucks. This is increasing transport and procurement costs as shown by the relationships in Figure 8.41. These changes further reduce the competitiveness of domestically produced sugar with cheaper imports.

This increasing distance-cost relationship puts pressure on company profit margins. The companies in turn pass on either higher transport fees or lower product prices to farmers, particularly those located in more distant, difficult to access locations.

Future work could undertake extended economic and isochrone analyses using the transport distance – cost relationships generated here to assist local Government, the Sugarcane and Sugar Industry Association, and the Son La Sugar Company with industry planning. For example, analyses could:

- Calculate a surface of break-even prices (i.e., equal to cost-of-production) for traders and collectors to break-even for different wholesale price and distance-cost scenarios;
- Identify the potential sugar production areas for development that have the lowest transport costs, and highest margins for farmers, collectors, and traders;
- Evaluate different investment and innovation scenarios such as land aggregation, road capacity upgrades, and cane handling and transport innovations (e.g., larger trucks and use of trailers) to improve competitiveness and profit margins along the chain.

This sugar cane case study approach could also be applied to any of the other crop supply chains, and in effect produce the economic catchment for commodities where it is cost effective to grow. Food processors could use this analysis to understand where the optimal location to place their processing infrastructure, or where to lobby for road upgrades

Relationship between district-level poverty and transports costs – supporting commune road upgrade decision making

This example demonstrates how TraNSIT analyses can be used to explore linkages between district transport travel times, costs and poverty rates. It also provides some insights into how TraNSIT could be adapted and extended to assist Government planners evaluate the potential economic and social benefits resulting from constructing new roads or rehabilitating existing roads to communes. There is broad evidence that improving road access to remote rural communities improves their connectivity to markets, health, education and community services, and employment opportunities. This in-turn supports livelihood improvement and reduction in rates of poverty (Van de Walle, 2009; Mu and Van de Walle, 2011 and Gibson and Olivia, 2010).

A key government strategy to reduce poverty in Vietnam is improving rural road infrastructure and connectivity with urban centers. For example, the Network Improvement Project (NIP) aims to improve rural road networks in Northern provinces in Vietnam. By doing so, the project expects to (i) reduce road transit times in selected rural areas in northern Vietnam; (ii) reduce vehicle-operating costs; (iii) improve overall road access to poor and isolated agricultural communities; and (iv) facilitate the delivery of goods from agricultural production centers to market (MOT 2004).

As a result the number of communes remaining to be connected by a sealed road is a key reportable performance measure for Provincial and District PPC and Department planners (e.g, DOT and DPI). However, road upgrades to communes must be prioritised and only implemented when funds become available. Often the most distant and difficult to access communes remain poorly linked to district and provincial road networks. These communes often suffer the highest rates of poverty and disadvantage.

TraNSIT was used to calculate the cost of travel for a 4T truck calculated from the highest population density in each district (assumed to be the main district town) to the point where the national highway (QL6) crosses Son La Province into the neighbouring Hoa Binh Province. Figure 8.42 below shows the relationship between district travel cost (x axis) and poverty rate (y axis). A weak correlation (R 0.23) indicates that the closer to the highway, the lower the poverty rate.

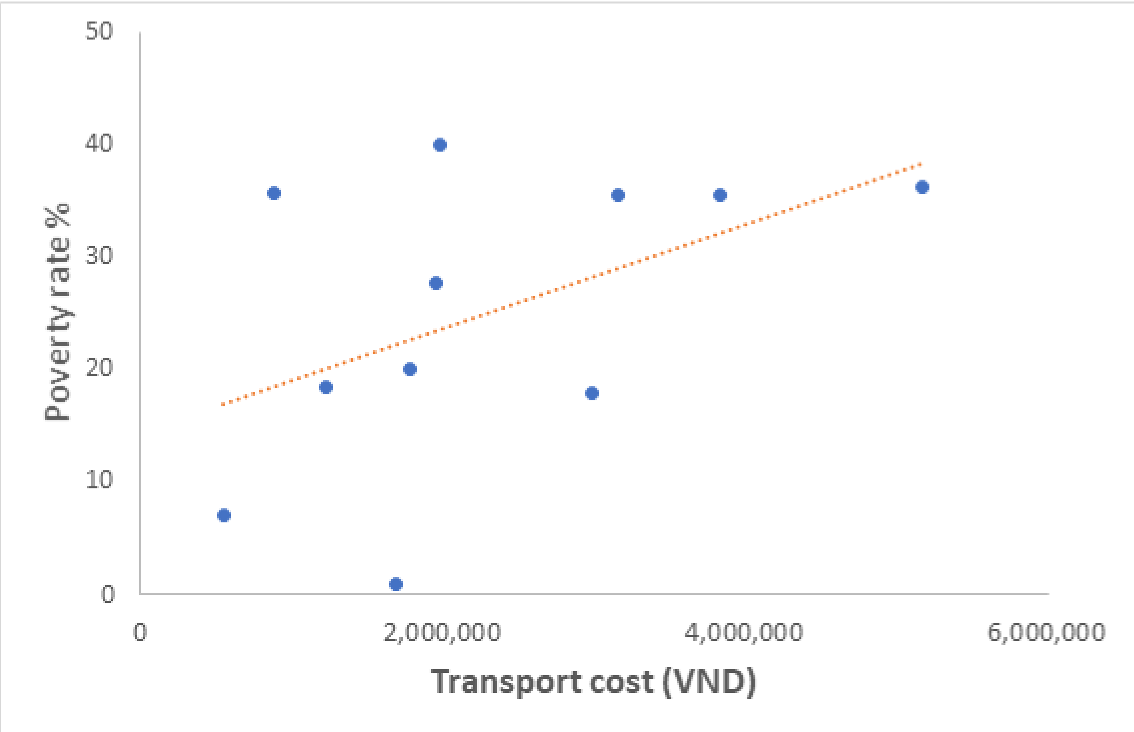


Figure 8.42 Relationship between poverty rate and transport cost to exit point on national highway (QL6) from districts, Son La Province

Starkey and Hine (2014) provide strong evidence that providing basic road connectivity to rural villages can generate significant social and economic benefits. However, they also flag recent evidence that investment in urban and rural roads tend to benefit the non-poor the most. Van de Walle (2009) likewise notes that beneficial impacts of road projects are mediated by other interactions – how the road links to other infrastructure, geography, community characteristics. Though road infrastructure projects often focus on linking households to nearby hubs and markets, little attention is given to the broader system of production, freight connections and demand dynamics that also influence how smallholders can participate in, and benefit from, local markets and supply chains (Van de Walle 2009). Therefore, to avoid creating further disadvantages, planners must consciously design investments with the poor in mind.

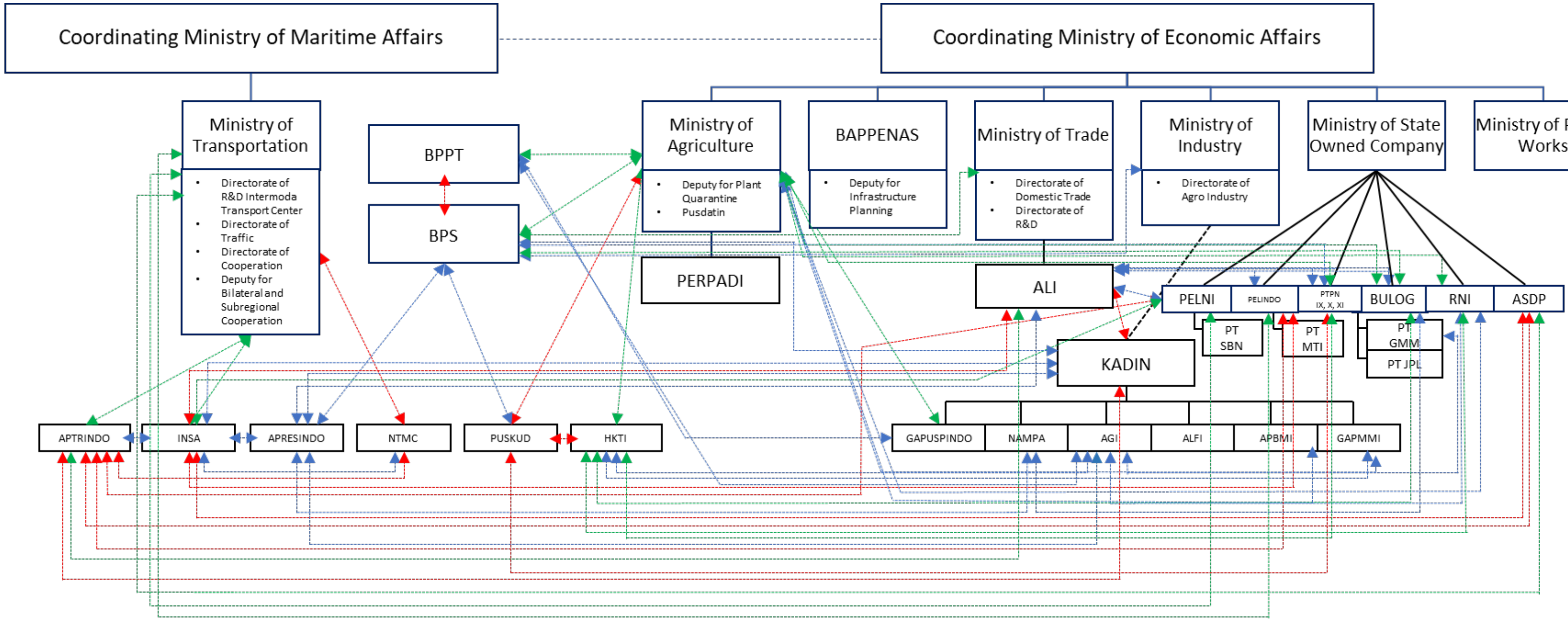
Whilst the TraNSIT example above is quite simplistic, more sophisticated simulations and relationships at the commune level can be conducted that better incorporate the needs of poor remote communities. These could particularly explore relationships between transport costs, agricultural market development opportunities and potential social and livelihood benefits based on human population, poverty rates and other demographic data available at the commune level. This would enable planners to consider a wider range of economic and social impacts of road upgrades more objectively, to better connect isolated communes against the expected investment costs.

8.2 Objective 2. Develop an understanding of the links between infrastructure, relationships and institutional aspects of transport bottlenecks, and understand critical stakeholders and collaborators who will translate outputs into impact

8.2.1 Indonesia

In Indonesia, the bureaucratic landscape is complex, with counterparts often acknowledging that communication and coordination amongst agencies challenging, particularly where data and information is concerned. A review of the engagement and development space was carried out with a map of key ministries, state-owned companies and industry associations for the project being prepared by the Indonesia-based team and is presented in Figure 8.43. These stakeholders were identified as key to supporting scenarios, data collection and longer-term use of TraNSIT. The project has achieved commitment from key ministries, research agencies, state-owned companies and industry associations. It has also achieved major progress in the necessary data gathering to provide “proof-of-concept” scenarios.

Immediately prior to this project’s commencement (i.e. September 2017), a “high level” round-table meeting was held in Jakarta at the Co-ordinating Ministry of Maritime Affairs. Representatives were present from many of the key ministries and state-owned companies. With these attendees, the round-table approach provided an effective means to introduce TraNSIT and the goals of the project, as well as to facilitate cross-stakeholder discussions. However, following the initial round-table meetings, bilateral meetings with individual ministries and companies proved a more effective way to engage in detailed discussions. Continued engagement across different government entities was critical to ensure ongoing involvement, and the project team continued to focus ongoing high-level engagement with key agencies, including BAPPENAS and the Coordinating Ministries, while communicating with line ministries on critical details.



Legend:

- Formal Partnership Role (project, funding, advisory)
- Cooperative Role (meetings, discussions)
- Sectoral Linkage (no official link)

List of Key Private Companies

Study case: Beef

Name of Private Company
PT Santori
PT Juang Jaya
PT Widodo Makmur Perkasa
PT Great Giant Livestock

Study case: Sugar

Name of Private Company
PT The Sugar Company (Gulaku)
PT Pabrik Gula (PG) Terpadu Glenmore
PT Gunung Madu

Study case: Rice

Name of Private Company
PT Indo Beras Unggul
UD Thejawijaya
PT Padi Unggul Indonesia
PT Lumbung Padi Indonesia

Figure 8.43 Stakeholder map for applying TraNSIT to Indonesian transport. Produced by PT Mitra Asia Lestari

The Indonesian Ministry of National Development Planning (BAPPENAS) oversees most of the national development policy for logistics and transportation in Indonesia and oversees the organisations (e.g. BPS) who collect and maintain key production and supply chain data sets. A MoU has been agreed[9] between BAPPENAS and CSIRO for co-operation in:

- benchmarking existing logistics of key commodities, identifying pinch points from paddock to plate;
- evaluating and optimising logistics arrangements from production through to processing, storage (including centralised warehousing options) and retail in order to ensure efficient operations from paddock to plate;
- prioritising investment and identifying inefficiencies;
- identifying critical infrastructure and testing upgrades to transportation route infrastructure, including road improvements, bridge construction, ports and shipping routes;
- providing transport freight flows and costs, and testing impacts for upgraded fleets including truck, train and shipping fleets; and
- providing costs and freight flows of policy setting and testing policy changes.

Co-operation under the MoU will include:

- exchange of information and data for mutual benefit;
- exchange of high-level delegations to discuss matters of mutual interest;
- capacity building, education, training, and knowledge sharing activities;
- development of science and technology, exchange program of research staff and trainees, research projects and technology sharing;
- interactions through meetings, conferences and symposia of mutual interest.

The state of partnership development through this project with each agency is as follows:

<u>Key Stakeholders</u>

BAPPENAS

The National Development Planning Agency (BAPPENAS) is an Indonesian non-ministerial government agency that is responsible to the President. BAPPENAS oversees development plans making, implemented by other ministries/agencies. BAPPENAS has several functions:

- Formulating and stipulating policies in the fields of national development planning, national development strategies, sectoral, cross-sectoral and cross-regional policy directions, as well as a macroeconomic framework that includes an overall picture of the economy including the direction of fiscal policies, regulatory frameworks, institutions and funding.
- Coordination and synchronization of policy implementation in the field of national development planning and budgeting.
- Fostering and providing administrative support to all organizational elements within the Ministry of National Development Planning.
- Management of state property/assets which are the responsibility of the Ministry of National Development Planning.

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[9] *Agreed though not yet signed due to physical constraints of COVID-19*

- Supervision of the implementation of tasks within the Ministry of National Development Planning.

Numerous positive meetings were held with BAPPENAS officials, including several with the former Secretary, who was extremely supportive of the TraNSIT program. In initial discussions, officials noted that it was aligned with the Master Plan Indonesia 2015 – 2025 and would certainly assist Indonesia develop more efficient and effective planning around logistic and transportation needs.

Ministry of Agriculture (MoA)

The Ministry of Agriculture has several functions, including formulation, stipulation, and implementation of policies specific to the agricultural sector, managing assets, implementing technical guidance and supervision of regional affairs under the responsibility of the Ministry, and implementing technical activities related to agriculture on a national scale. There are multiple agencies and sections with varying responsibilities, within the Ministry of Agriculture, however, the two of particular importance for the TraNSIT project includes the Indonesian Agency of Agricultural Research—a long term partner of ACIAR—and the Data and Information Centre (Pusdatin).

MoA: Indonesian Agency of Agricultural Research and Development (IAARD)

The Indonesian Agency of Agricultural Research and Development, the research arm of the Ministry of Agriculture, is focused on producing and developing technological innovations and policy recommendations in the agricultural sector and improving the quality of agricultural research resources, including improving the efficiency and effectiveness for end users. IAARD is focused on a resource-oriented approach, generally concentrating on identified and specific needs within the agribusiness sector. While the Agency has been previously focused up to the farm-gate, they have more recently focused on a market demand approach. Our in-country coordinator met with the previous Secretary for the Director General of IAARD, who was supportive of the work and keen to work with CSIRO to develop TraNSIT for Indonesia. BAPPENAS had also noted they would be keen to work in coordination with IAARD and its agencies as they had the research and technical knowledge and skills.

MoA: Data and Information Centre (Pusdatin)

The Center for Agricultural Data and Information Systems (Pusdatin), Ministry of Agriculture, is the source of key up to date agricultural data and information, collected to support agricultural development. Their main tasks are to carry out guidance, processing, analysis and development of agricultural information systems as well as services and publication of agricultural data and information. In meeting with Pusdatin officials they noted that TraNSIT was the kind of tool needed to increase the efficiency of agriculture supply chains. They provided an overview of their public information, noting they were happy for CSIRO to use it, and provided contact should additional information be requested.

Coordinating Ministry for Maritime Affairs and Investment

The Coordinating Ministry for Maritime Affairs and Investment is the Indonesian government ministry in charge of planning, coordinating as well as synchronizing policies in maritime and investment affairs. Their duties are to coordinate, synchronize, and control ministerial affairs in the administration of maritime and investment governance. Technical line ministries under their coordination include the Ministry of Transportation, Ministry of Maritime Affairs and Fisheries, Ministry of Tourism and Creative Economy, and Ministry of Energy and Mineral Resources. Senior officials within the Coordinating Ministry were particularly supportive of the project, as they were focused on reducing logistic costs by 30%. Additionally, they were appreciative of the tools functions as they understood its utility to enable policy makers to make informed decisions regarding infrastructure investments. A key function of the Ministry.

Coordinating Ministry for Economic Affairs

The Indonesian government ministry in charge of planning and policy co-ordination, as well as synchronisation of policies in the fields of economics. The Coordinating Ministry for Economic Affairs has the task of coordinating, synchronizing, and controlling administrative, and governance matters in the economic sector. Key functions include:

i. formulation, coordination and implementation of policies from Ministries/Institutions related to the economic sector,
ii. managing and resolving key issues related to the economic sector, and
iii. guiding national priority programs and key policies presented by the President and Cabinet.

Technical ministries under their coordination include, the Ministry of Finance, Ministry of Industry, Ministry of Trade, Ministry of Agriculture, Ministry of Manpower, Ministry of Cooperation and Small & Medium Enterprises, Ministry of State Owned Enterprises, Ministry of Public Works and Public Housing, Ministry of Land and Spatial Planning, and the Ministry of Environment and Forestry.

The Deputy Minister for Food and Agriculture within the Coordinating Ministry of Economic Affairs has expressed interest in the project from the beginning, initially guiding the team's engagement and then later providing support and assistance where needed.

<u>Important or Supporting Ministries and Agencies:</u>

Ministry of Transportation

The Ministry of Transportation formerly Department of Transportation is a government ministry responsible for the governance and regulation of transport in Indonesia. In the last five years, the Ministry of Transportation has developed transportation infrastructure with an Indonesia-centric approach to reduce isolation, namely by providing accessibility support for Outermost, Frontier, Disadvantaged and Border Areas. Among them are by providing infrastructure, namely 18 sea highway routes to reduce price disparities in Eastern Indonesia, 891 pioneer transportation routes (road, river, lake, rail, sea and air transportation), and the construction and development of 131 airports in disaster-prone areas, borders, and isolated.

The Ministry of Transportation has several functions including developing, and implementing transportation policy, executing national level technical assistance in the field and supporting regional level transportation aspects. Similar to much of the engagement with other agencies, officials from the Ministry of Transportation could envisage the utility of the tool, often noting it aligned with both Indonesia's needs and the President's mandate of building infrastructure to support economic growth. Furthermore, they were appreciative of the tools ability to support government make decisions towards reducing logistic and transportation costs. They were also particularly interested in the TraNSIT projects ability to provide:

i. capacity and volume information,
ii. identification of routes that should be followed by trucks according to their type, and
iii. information about transportation logistics.

Central Statistic Agency Indonesia (BPS)

The Central Statistics Agency (BPS) is a Non-Ministry Government Agency directly responsible to the President. Previously, BPS was Biro Pusat Statistik or Central Bureau of Statistics (CBS) instituted by Law Number 7, 1960 on Statistics. Under the Government of the Dutch East Indies, (February 1920) the Statistical Office was first established by the Director of Agriculture and Trade (Directeur van Landbouw Nijverheid en Handel) and is based in Bogor. Given the long history in agriculture it serves a critical function and could be a key relationship for the project and future implementation.

BPS has several functions including provision and analysis of data to both the government and public with a key focus on periodic information concerning the structure and growth of the economy, social change, and development. They both perform their own research and surveys as well as obtaining necessary information and data from other government departments. They provide assistance to statistics divisions of government departments and other institutions, and develop and promote standards to be incorporated in the implementation of statistical techniques and methods, and to provide necessary services in the field of education and training in statistics. Furthermore, they are keen to establish cooperation with international institutions and other countries for the benefit of Indonesia's statistical development.

BPS were particularly impressed with the way TraNSIT worked and was always available and supportive to CSIRO data and information needs.

Ministry of Trade

The Ministry of Trade has the task of carrying out trade affairs for the government, including maintaining price and supply stability of staple foods, supporting the development and implementation of international trade agreements at the bilateral, regional, and multilateral levels, and formulating and implementing policies in both domestic and international trade. They are also involved in implementing technical guidance and supervision over the implementation of policies and practices in both domestic and international trade.

Agency for the Assessment and Application of Technology (BPPT)

The Agency for the Assessment and Application of Technology Indonesia (BPPT) is an Indonesian Non-Department Government Institution under the coordination of the Ministry of Research, Technology and Higher Education. BPPT is focused on the assessment and application of technology and monitors, guides and services other government agencies and private organization in their application of technology. They are focused in the areas of evaluating technology policy development, natural resources, agroindustry and biotechnology, and technology development in information, energy, and engineering industries.

BULOG

State-owned company in Indonesia which deals with food distribution and price control.

The Indonesia Logistics Bureau (BULOG) was founded in 1967 with its initial purpose focused on securing food supply following the chaotic events caused by extremely high inflation in 1966. Currently, BULOG is a state-owned company engaged in food logistics, with the key role focused on storing and distributing key staples, particularly rice. Their focus is maintaining a stable price and ensuring supply and distribution to the poor. They have become more involved recently with sugar, soybeans, meat, fish and other commodities.

8.2.2 Vietnam

The aim of this project was to evaluate the opportunities to reduce transport and logistics costs to small-scale farmers. It also aimed to support more informed policies on infrastructure that promote rural development and improved connectivity of rural communities to agricultural markets in Vietnam. The long-term outcome defined in the theory of change was for key stakeholders and agencies in Vietnam to have acquired the necessary capacity, skills and access to analytical tools such as TraNSIT to support evidence-based transport and logistics planning, policy and infrastructure investment decision making.

An impact pathway to achieve outcomes in these sectoral impact areas is presented in Figure 8.44. This describes the links between various institutions and transport infrastructure decision making at different administrative scales. It also identifies critical stakeholders and collaborators.

Four main institutional and sectoral impact areas for TraNSIT in Vietnam were identified:

1. National level Government transport policy, planning and investment decision making;
2. National level Government agricultural policy, planning and investment decision making;
3. Provincial and district-level Government transport and agricultural investment, planning and decision making;
4. National and local level planning and decision support to transport, agribusiness industry and the private sector.

Four ultimate impact areas representing four end-user groups were identified (yellow boxes in Figure 8.44). At the national level, the Ministry of Transport (MOT) is responsible for transport infrastructure while the Ministry of Agriculture and Rural Development (MARD) is responsible for agriculture and rural development. At the provincial and district levels, the Provincial and District People's Committees and the underlying Ministry Departments are key end-users responsible for planning, investment, and policy support. Finally, industry associations and lead transport, logistics and agribusiness firms or apex buyers are important and influential private sector end-users, at national to local-level scales.

A major challenge for developing and applying analytical tools like TraNSIT is to identify key partner agencies, stakeholders, and collaborators from across these Ministries capable of both undertaking technical analytical work and translating outputs into impacts at these different scales. As is often the case in broad Government bureaucracies, planning, policy, and decision-making responsibilities for transport infrastructure investment in Vietnam cuts across different Government Ministries and depends on the administrative scale of jurisdiction. Which agencies and collaborators, both inside and outside these Ministries, are appropriate to engage is also influenced by whether work is being conducted at the regional, national, provincial, district or commune administrative scales.

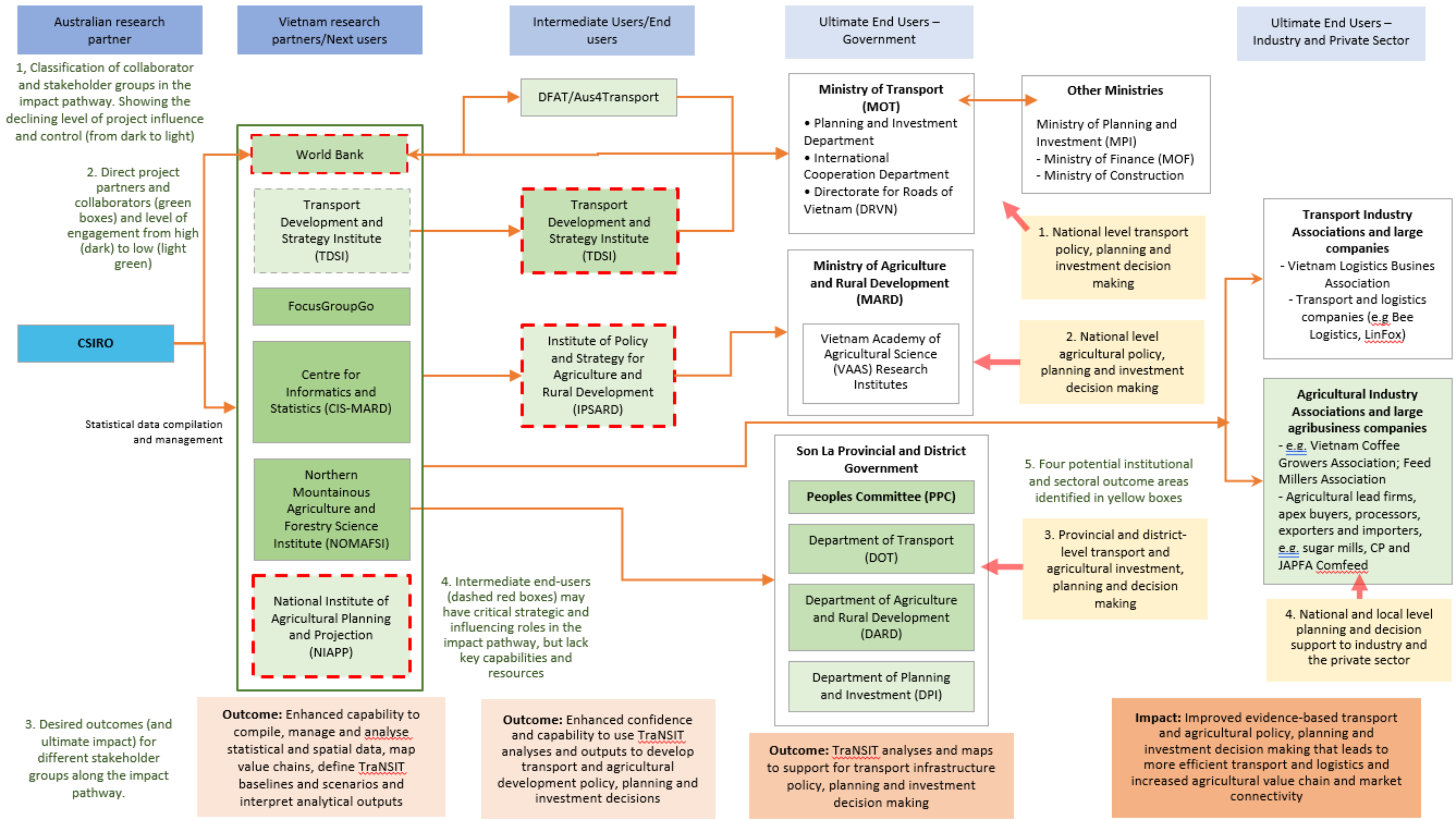

Figure 8.44.Project collaborators and next, intermediate and end users for achieving decision making and planning outcomes from TranSIT

The key Vietnamese government stakeholders identified in the impact pathway are:

Ministry of Transport

The Ministry of Transport (MOT) has primary responsibility for developing transport sector master plans and strategies, and the operation of the transport network in Vietnam. This is done through multiple Administrations and project units for road, railways, inland shipping and maritime, and aviation. Operating under the Ministry structure, Departments of Transport (DOT) operate at provincial and district government levels and are responsible for provincial and rural transport.

The **Institute for Transport Strategy and Development (TDSI)** is the main research agency within the MOT. The agency is responsible for formulating national transport development strategies, plans and policies across all transport modes and sectors, and providing transport research and technological advisory services to MOT. Because of its strategic, research and advisory mandate to MOT, TDSI was identified as a key next and intermediate-user and project collaborator.

Within the MOT, the **Directorate of Road for Vietnam (DRVN)** is responsible for advising and assisting the management and regulatory enforcement of road traffic nationally and organising the implementation of public road transport services. DRVN would be a typical end-user agency within the MOT, particularly in relation to results from scenarios and option analyses to alleviate transport bottlenecks and traffic congestion in the national road network. DRVN is also responsible for the administration of the Commercial Vehicle Tracking System (CVTS), which collects continuous GPS position data from over one million commercial vehicles in Vietnam and has potential as an extremely valuable resource for providing information on vehicle location, road usage and road speed across the road network. To date, this CVTS data has only been used to investigate traffic and vehicle infringements, however World Bank, DRVN and CSIRO are currently assessing this data to determine its potential use for a wide range of transport analysis.

Other Ministries

Other Ministries and agencies are also involved in transport infrastructure planning, investment and construction often in coordination with the MOT. The Ministry of Planning and Investment (MPI), is responsible for socio-economic planning, coordinating international development assistance, appraisal of development studies and coordination roles in relation to public-private partnerships (PPPs). The Ministry of Finance (MOF) sets the national government budget and is responsible for oversight of all public assets and for the finances of state corporations. The Ministry of Construction (MOC) is responsible for design and construction standards, and price norms that underpin the estimation of project costs, and assessment of tenders for transport construction projects. Whilst important to understand their roles in transport infrastructure planning, financing and construction, they were not considered key end-users.

Ministry of Agriculture and Rural Development

The Ministry of Agricultural and Rural Development (MARD) agencies are essential end-users and collaborators because of the focus in this project on improving connectivity of smallholder farmers and supply chains to agricultural markets. MARD is responsible for planning, policy, research, and regulation relating to agricultural production, processing, purchasing and distribution of food throughout the country. Key strategic policy goals for MARD include improving competitiveness, increasing innovation and technology, creating added value and strengthening market connectivity in agricultural supply chains.

Operating under the Ministry, Departments of Agriculture and Rural Development (DARD) are responsible for agricultural sector development planning, regulation, and extension at provincial and district levels.

The Institute of Policy and Strategy for Agriculture and Rural Development (IPSARD) was identified as a key national-level next user. This is mainly because of

IPSARD's role as the premier policy research think-tank under MARD and its mandate to provide advice and develop strategies, policies and master plans for the development of a more competitive and sustainable agricultural sector. The development of strategic hubs for agricultural product aggregation, processing, marketing, and distribution is a key topic area currently being examined within IPSARD. This is also an area where TraNSIT analyses and outputs can provide some insights.

The Vietnam Academy of Agriculture Science (VAAS) is the national umbrella research agency under MARD with the function of coordinating and implementing scientific research, technology transfer, consulting, services, international cooperation and graduate training in the fields of agriculture and rural development. VAAS overseas nineteen different agricultural research institutes that have either sectoral, geographic, or thematic mandates. Within VAAS, the project engaged the Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI) as a key collaborator (see below).

Multilateral development banks and bilateral donors

The multilateral development banks such as **World Bank** and **Asian Development Bank (ADB)**, and bilateral donors such as **DFAT** and **JICA** are also key stakeholders in transport infrastructure planning, investment, and development in Vietnam.

The World Bank in particular, collaborates closely with the Ministry of Transport in strategic planning, technical assistance, capability development and provision of concessional loans for transport infrastructure. The World Bank is also a major beneficiary and coordinator of funding from DFAT for transport sector improvement. The World Bank and DFAT's Aus4Transport program were identified as key next users and possible collaborators due to close alignment between their current transport related goals and activities and the outcomes being sought from TraNSIT.

In Vietnam, direct grant funding of infrastructure is no longer essential. Concessional loans from the multilateral development banks, bilateral donors and, increasingly, funding from private sources are now possible. However, DFAT (see https://www.dfat.gov.au/about-us/publications/Pages/vietnam-aus4transport-fact-sheet) has identified the need to improve the preparation processes of infrastructure projects in ways that will demonstrate the economic and financial viability to investors, reduce risk and enable capital expenditures to be prioritised.

To address these issues, the DFAT funded Aus4Transport program with the MOT is seeking an outcome of *faster project development and improved quality of transport infrastructure making use of funding from all financial sources.* This will be achieved by supporting MOT capability to (i) bring better prepared proposals and concepts more rapidly to implementation drawing on innovative and comprehensive approaches; and (ii) adopt innovations in policies and procedures that lead to improved project development. The goal of Aus4Transport is increased investment in Vietnam's transport infrastructure, leading to an enhanced transport system that supports economic growth and poverty reduction. TraNSIT can clearly support investment evaluation and decision making.

Key Project Collaborators and Next Users

To understand the relationships of different stakeholders and agencies and how those relationships on the ability to collect data and adapt and apply the TraNSIT model to evaluate how it may support transport planning and investment decision making, we focussed on Son La Provincial and District Governments. This required engaging with institutional partners and researchers with access to both agricultural and transport statistics, with technical knowledge about the agricultural supply chains in Son La province and with established networks with Son La Government institutions. It also required engaging directly with the provincial and district level governments and the key commodity-linked agribusinesses in Son La. The key roles of the main project institutional collaborators and next users is summarised in Table 8-13. A major capacity gap across all partner institutions was a lack of computer programming, modelling and GIS analysis capability (See section 8.3.2 for further information).

The **Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI)** under VAAS/MARD was a valuable project partner in Son La. NOMAFSI is responsible for scientific research and technology transfer in agriculture for the development of the Northern Mountainous Region. They have an established and significant research presence in Son La Province, extensive knowledge about local agricultural supply chains, are locally respected and networked and have been a close research collaborator on ACIAR projects across multiple commodities for many years. These characteristics made NOMAFSI, or a local-technical VAAS partner like them, essential for engaging at provincial and district scales.

The **Centre for Informatics and Statistics (CIS)** under MARD was an essential partner for identifying, compiling, and managing agriculture statistics including production data, import-export data, and agricultural enterprise data sets. CIS is responsible for the collection, analysis and reporting of industry statistics to MARD. The centre works closely with the General Statistics Office (GSO) and MAR Departments in the provinces and districts that provide a data collection network.

The **Institute for Transport Strategy and Development (TDSI)** was able to provide higher level support with transport strategies and statistics. However, like NOMAFSI and CIS, TDSI lacked advanced capability in computer programming and GIS analysis, and spare human resources to commit significantly to project implementation. The ability of TDSI to source, compile and maintain the range of both transport and agricultural production input data and to apply these in TraNSIT across multiple transport modes – road, rail, inland waterway etc. was also considered a major challenge.

The **National Institute of Agricultural Planning and Projection (NIAPP)** could be an important next-user and partner for future work. An agency under MARD, one of NIAPP's roles is to formulate and implement strategies for agricultural and rural development accompanied by the protection of the environment. For example, NIAPP has recently published development strategies for pepper, coffee, livestock breeding and catfish sectors. It was not possible to collaborate with NIAP during the project as we only established a relationship with them late in the project. However, consultations with NIAPP indicated that some staff in the Division of Rural and Agricultural Planning have skills in computer programming, spatial analytics, and GIS mapping, that were not present in other institutions.

Provincial and District Government

The People's Committee in Son La Province (PPC), and the districts of Mai Son and Moc Chau were essential initial points of engagement and end-users for the SRA. They provide a critical coordination and endorsement role with the Departments of Transport (DOT), Planning and Investment (DPI) and Agriculture and Rural Development (DARD) in each location. An initial set of briefings and consultation meetings about TraNSIT were held with provincial officials and relevant Departments in Son La, as well as in Mai Son and Moc Chau districts. These consultations were followed by a central workshop which demonstrated TraNSIT analyses and outputs and identified a range of potential scenarios for analysis.

Planning and investment in road infrastructure is overseen by the Peoples Committee and Departments (MPI and DOT) operating at each province and district level. A detailed road transport development plan guides investment and upgrading of national, provincial and district roads over a ten-year horizon.

Table 8-13 Summary of key roles for project collaborators and next/intermediate users

PROJECT COLLABORATORS/NEXT USERS	ROLE
CSIRO	Data manipulation, computer programming, spatial optimisation modelling, GIS analysis and mapping
NOMAFSI	Supply chain product and transport mapping, stakeholder engagement, GIS mapping and scenario development
CIS	Agricultural statistical data acquisition, compilation and management
FocusGroupGo	Partner coordination, data compilation and scenario development
Son La Provincial People's Committee (PPC), DOT, DARD, and DPI	Road investment processes, plans and strategies, agricultural development plans, access to agricultural statistics, defining development scenarios, engagement with the private sector
Key Intermediate/Next Users for national and upstream engagement	
TDSI	National transport data, policies and plans, scenario definition (national)
IPSARD	Agricultural research, policy, and strategy development (provincial and national)

Intermediate Users

Whilst less relevant for this SRA, the research institutes TDSI (for MOT) and ISPARD (for MARD) were identified as key Next Users for national-level outcomes due to their strategic policy and research functions and advisory responsibilities to their respective Ministries. These institutions, (amongst others) could be key participants in a collaborative big-data and spatial analytics research and innovation centre discussed proposed in the next section.

8.3 Objective 3. Understand the capital, skills and equipment requirements to establish TraNSIT.id and TraNSIT.vn within country.

8.3.1 Indonesia

Similar to the establishment of TraNSIT within or across institutions in any country, effective integration requires a team of researchers and analysts with access to a broad range of information and data, appropriate coordination, communication and consultation mechanisms, and multiple skill sets and capabilities (see 8.2.2 Vietnam).

Several meetings in Indonesia highlighted changes to a more centralised system due to the Satu Data Indonesia (One Data program, data.go.id), where Pusdatin in conjunction with other technical ministries and GIS Spatial Agencies use the new method in collecting data, which is then verified and published by BPS. Ministry of Transportation has collected logistics data for 33 commodities and indicated they do not yet have a plan on how best to use the data to improve logistics outcomes. Both BPS and Ministry of Transportation confirmed an interest to participate in workshops to review their data and determine if and how it could be used to improve logistics.

BPPT was working on supply chain mapping for Economic Special Zone (KAPET), including developing master plans for transportation for certain commodities. However, their access to data appears to be limited to seeking it from other ministries or collecting it directly through project specific activities.

Discussions with industry revealed their belief the current logistics is poor and expensive and without a baseline it is difficult to identify opportunities for productivity improvements. Industry additionally pointed out the challenges of domestic logistics particularly interisland was expensive and uncertain, and aside from the sea leg, the road conditions are poor and compounded by seasonal access issues. The poor transport infrastructure and logistics impact on both farm inputs and outputs. They also believe there is a need to target investment to make the agriculture supply chain more efficient, and in being able to quantify regulatory compliance including local regulations and unofficial costs. This is seen to be a particular concern and impost on SME's where they struggle to contend with changing and uncertainty regulatory conditions and have little ability to influence.

Data storage capabilities exists in all ministries but the key challenge is the method used to collect data, the validation of the data's accuracy, and the inconsistency because of different methods of any data currently available. The key capability limitations identified by Agencies is the communication and coordination processes to ensure a national level approach is provided which can filter down to the regional level.

GIS and modelling capabilities exist in the research arms of many of the ministries, such as BPPT. However, collaborative programs and training would no doubt be needed to further develop the models utilised in TraNSIT and to ensure skills and capacity were transferred to ensure the continuation of the tool long after any funded program came to an end.

As part of the regular meetings, discussions and roundtable held throughout the life of the project, an initial qualitative assessment of capabilities for each of the key institutes was mapped (Table 8-14)[10]. The assessment highlights the higher technical capabilities of the research, data and technology arms or agencies above that of the coordinating and planning agencies. Technical ministries, such as agriculture and transportation, have sections devoted to data and analysis, as well as sections devoted to developing and implementing policy specific to their sector. Scientific agencies have the capabilities for mapping, analysis, and modelling, but not necessarily the data, nor the ability for direct influence into policy. Coordinating and Planning ministries have general understanding of the data, potential for mapping and analysis, and the ability to influence high level policy decisions, but may not have authority over sector specific policy decisions. However, the later agencies have a greater ability for utilising the information for policy implementation. These key functions amongst technical ministries, scientific agencies, and coordinating and planning ministries means significant coordination, communication and consultation is needed for further development of TraNSIT in Indonesia.

While there is some capability regarding modelling and GIS within the institutes engaged over the life of the project, it would be envisaged that processing data, model development and parametrisation, simulations, mapping and evaluating outputs would need considerable training and ongoing mentoring, and support to ensure not only ownership of the tool in Indonesia, but also its ongoing utility.

Additional, and not inconsequential challenges that were proffered during the discussions, meetings, field work, and roundtables also include:

- Limited mechanisms for holistic, effective and efficient coordination (i.e. most discussions with Government, Research Agencies, State-Owned Enterprises, Industry and Industry Associations led to 'should speak to…..' statements rather than taking ownership of the issues).
- Recognition that length of supply chains can be substantial and significant differences in supply chain models exist between locations, and as such good regional government agency engagement and data are also required .
- Some of the data may not always representing what happens at the farm level, and a verification process needs to be included.

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[10] *final confirmation of this assessment was delayed due to COVID. A detailed final workshops are still envisaged as part of ongoing CSIRO-BAPPENAS engagement.*

- The underdevelopment of road networks (including constraints around connectivity – i.e., major roads to minor roads and farmers access to markets etc.) is complicated by complex policy approaches to develop transportation infrastructure and reduce congestion.
- Multiple agencies, including both government and state-owned enterprises (e.g., PT PELNI) involved in critical aspect of the trade and logistics of agribusiness products results in overlap and duplication of responsibility.
- Government objectives are in flux, with agencies take on more responsibility as Indonesia's economy grows (and recovers from the COIVD-19 pandemic). This will result in constant staff movements which will pose a challenge for the communication, consultation and implementation of TraNSIT. But there will also be a high level of focus on improving transportation and logistics efficiencies, with the goal of cutting overarching logistic costs from 24% to 8.5% and reducing the overall cost of transporting agriculture products creates a need for significant communication and consultation processes.
- Timing of production meeting demand periods such as religious holiday periods which can drive demand up by more than 30%, is a unique Indonesian challenge, especially where ethe Government aspires to maintain price stability and parity across the country.
- Data access, especially by a foreign government entity like CSIRO, is sensitive and therefore ongoing access and security will need consideration, understanding amongst partners and likely the need for explicit data sharing agreements.
- Data is not always agreed between agencies nor complete, plus different agencies have different focus and therefore collection, storage and analysis will not always be similar.
- Unofficial costs for the movement of goods and access to infrastructure needs to be accounted for, and the existing of grey channels of trade and movement are also likely.

Table 8-14 Qualitative assessment of capability in key skill areas* linked to spatial analytics and optimisation modelling within partner institutions in Indonesia .

Skill area	BAPPENAS	Ministry of Agriculture		BPS	Coord Ministry of Economic Affairs	Coord Ministry of Maritime Affairs	Ministry of Transportation.	BPPT	Ministry of Trade	Ministry of Public Works and Housing
		IAARD	Pusdatin							
Management and manipulation of very large statistical data sets	2	3	3	3	1	1	2	3	2	2
General computer programming and coding capability i.e., Python	1	3	3	3	1	1	2	3	2	2
Familiarity and use of large spatial data, databases, and software e.g., Post GIS	2	3	3	3	1	2	2	3	2	2
GIS and remote sensing analytics – ArcGIS/QGIS	1	3	3	3	1	1	2	3	2	2
Spatial analytics and optimisation modelling	1	3	1	3	1	1	2	3	2	2
Deep knowledge of agricultural supply chains	2	3	3	3	2	2	1	2	2	2
Deep knowledge of transport and logistics networks and investment	2	2	2	2	2	3	3	3	3	3
Ability to manipulate, analyse and interpret model output and integrate insights into decision making and planning	3	2	2	2	3	3	3	2	3	3

Initial estimate of specific technical capability within institutions in each skill area. 1= zero to limited, 2 = limited to moderate, 3 = moderate to advanced. Note these capabilities were to be validated through an in-country workshop, but COVID pandemic isolation postponed our ability to hold it, and with ongoing issues in Indonesia up to the time of writing, the workshop has not yet been finalised.

While the challenges are many and broad, there are also positive aspects that should provide for suitable partnerships and relatively clear approaches towards addressing skills and capabilities and providing solutions for cross-institutional collaboration. BAPPENAS have, in recent years, been provided the mandate of data storage, and by their very role associated with delivering Indonesia's broader development goals, provide for a solid partner. Additionally, the objective of a more unified approach to collection, analysis and presentation of data associated with transportation and logistics and the development and improvement of the associated infrastructure allows for the development of greater optimism towards improved collaboration. Additionally, key points from discussions with government, research agencies, state-owned enterprises, industry associations and industry (e.g. PT, PELNI, PT PELINDO, GAPMMI, KADIN, ALI, JAPFA, Bogasari, PT GMM, Sampoerna, PT RNI, APTRINDO, GAPUSPINDO) include:

- A common interest amongst all, and particularly a growing interest from all ministries to improve the system given the challenges and threats, and therefore a well-developed strategic approach, utilising current methods with improved technology and innovation that provides policy makers and industry leaders with an informed decision-making tool is clearly recognised as important.
- TranSIT offering an improve process to bring together an effective single approach system to track and trace agriculture commodities.
- The complexity of supply chains, the high logistic costs, the ongoing issue of disruptions and bottlenecks and the pricing differences across the country offer opportunities for small gains to provide large benefits.
- Backloading is underutilised and could provide for significant improvements where possible.
- Infrastructure development plans are significant and yet investment is often limited and therefore focusing on those aspects that will provide greater benefit is seen as important.
- Government is beginning to examine current policy making approaches and systems, particularly considering recent global events, including many agencies focusing on the agriculture sector, costs, movement of produce, imports and exports, food security improvements, noting 'availability' and 'affordability' are incorporated within the definition.
- Food production is not necessarily in demand, so transport needs are large, and with the plans to move the Capitol to a new location in East Kalimantan, movement of people and their needs will alter supply chains considerably in coming years.
- Demand side has altered significantly in recent times with the increase in e-commerce platforms (Tokopedia, Shopee) and home delivery services (Grab, GoJek) – even moreso under COVID conditions.
- Strong desire for more and greater use of innovative digital technology into the agriculture sector.

8.3.2 Vietnam

A range of factors that constrain the ability of relevant agencies to establish and integrate spatial analytical platforms like TraNSIT were identified (see Conclusions and recommendations on page 85). Probably the biggest challenge however relates to human capability. First, the establishment and integration of TraNSIT within or across institutions requires a team of researchers and analysts with a unique set of multi-and transdisciplinary expertise. This includes skills and knowledge in transport policy, planning and network analysis, agricultural supply chain analysis, statistical data manipulation and analysis, transport investment planning and policy, computer programming and optimisation modelling, spatial analytics, GIS programming and economics.

The level of capability in these skill areas was assessed qualitatively for each institution (Table 8-15). This assessment shows that each research institution typically has one or two areas of technical capability strength. Accessing the required skills to adapt and establish TraNSIT therefore requires partnering across multiple institutions and Ministries.

Secondly, there is limited or in some cases no available expertise in advanced computer programming and GIS within any of the partner institutions (perhaps except for NIAPP). This is a major barrier to establishing TraNSIT, as data compilation, processing, model parametrisation and simulation, post-processing and mapping tasks all rely on relatively advanced computer programming and GIS skills. Without available expertise within partner institutions, these tasks must be done entirely by CSIRO programmers and analysts (as occurred in this project) or outsourced. TraNSIT.vn web offers a partial solution – it is a simple Web-based interface which has been developed and allows a user to easily access and analyse model outputs and determine key freight statistics and metrics. With this product, only an understanding of the main spatial TraNSIT outputs, and how these can inform transport planning, is required. Beyond suitable funding to establish transit.vn web, the main challenges to rolling it out would be identifying a secure hosting server, providing and managing access to external users, and populating the database with modelled data.

Table 8-15 Qualitative assessment of capability in key skill areas* linked to spatial analytics and optimisation modelling within partner institutions in Vietnam.

Skill area	TDSI	IPSARD	NOMAFSI	CIS	NIAP (assumed)	Provincial/ District Govt.
Management and manipulation of very large statistical data sets	1	2	1	2	2	1
General computer programming and coding capability i.e., Python	1	2	1	1	2	1
Familiarity and use of large spatial data, databases, and software e.g., Post GIS	2	1	1	1	3	1
GIS and remote sensing analytics – ArcGIS/QGIS	1	1	1	1	3	1
Spatial analytics and optimisation modelling	1	2	1	1	2	1
Deep knowledge of agricultural supply chains	1	3	3	1	2	3
Deep knowledge of transport and logistics networks and investment	3	1	1	1	1	2
Ability to manipulate, analyse and interpret model output and integrate insights into decision making and planning	2	3	1	1	2	1

**Level of specific technical capability within institutions in each skill area. 1= zero to limited, 2 = limited to moderate, 3 = moderate to advanced, assessed via self assessment in a workshop setting.*

a) *Solution options for addressing institutional capability gaps*

Key capability gaps to establishing and integrating TraNSIT could be addressed in two ways:

i. Target suitable individuals within key institutions to develop the necessary in-house computer programming and GIS analysis capability.
ii. Access or embed the required level of programming and GIS expertise from other institutions or the private sector, and ensure that value of those skills are valued within the host institution.

Through projects like this, it is possible to provide technical support and mentoring to key in-house staff to improve GIS analysis skills, such as occurred with staff in NOMAFSI. However, this approach will not produce staff with the necessary level of programming or GIS skills in the short-term. Training and relying on just one or two key people also risks creating critical expertise gaps when they inevitably move on to other positions (as was observed during the project).

With external resourcing, it is possible to identify and appoint local programming and GIS expertise in a multi-institutional team that specialised in transport analytics. It was observed however that computer programming and GIS are also unfamiliar expertise areas amongst institutional Directors and section heads. Therefore, managers and embedded programming/GIS specialists may also require external mentoring and support to establish and manage these skill areas within their organisation, and it is possible to support this remotely, as observed during the COVID-19 travel restrictions.

b) *Solution options for addressing hardware and software gaps*

Whilst most institutions lack sophisticated in-house computer hardware and software ("the equipment"), there are relatively low-cost solutions that would enable spatial analytical platforms such as TraNSIT to be established in-house. Solution options include use of:

- Cloud-based computing services for off-site big-data storage and processing requirements (provided by reputable Vietnam cloud computing service providers);
- Open-source software for spatial data bases (e.g. PostGiS), programming (e.g. Python), and GIS analysis (e.g. QGIS)
- Remote processing of TraNSIT (e.g., on CSIRO servers in Australia) combined with remote access to analytical outputs via TraNSIT web.

Whilst comparatively cost efficient, these service solutions all require ongoing research operating funding. They also required competent and experienced data analysts and programmers.

c) *Solution options for resourcing and cross-institutional collaboration challenges*

Available funding for human and technical resources is a major constraint across all Government institutions in Vietnam. Existing staff and researchers are generally all heavily committed. Even if there were suitability skilled researchers within an institution, there are limited resources available to mobilise and commit these to a cross-institutional, multi-disciplinary spatial analytics team, as well as appoint or embed specialist programmers and GIS analysts.

With ongoing support from donors and funders, it is possible to continue to build confidence and capability of key partners in spatial analytics and further develop and apply TraNSIT to support planning and decision making in key Government agencies and the private sector. However, it is highly unlikely that a Government agency has the resources to set up an "in-house" TraNSIT or spatial analytics team due to the cross-institutional complexities, the high transaction costs, and lack of financial, human and capability resources.

A longer-term sustainable solution could be for World Bank and a bilateral donor such as DFAT or ACIAR to support the establishment or incubation of a cross-institutional spatial analytics and innovation unit or hub. This approach aligns closely with the Governments priority for digital transformation in the forthcoming Socioeconomic Development Strategy 2020-2030.

A spatial analytics and big-data hub or centre could be a public-private partnership between Government, research institutions, the investors/donors, and the private sector, both technology partners and end-users. Investor funds could initially be used to secure existing qualified staff or appoint new expertise into the unit for several years.

Resources to support onsite or remote mentoring and technical support from institutions such CSIRO would also be critical. The main role of this unit could be to undertake sophisticated big-data analyses and simulations and provide advice and information to the Ministry of Transport and other customers such as Provincial and District Governments, other Ministries, and agencies e.g., MARD and the private sector. Over time, if managed well, this entity could be spun off as an independent business.

Examples of successful cross-institutional collaboration and innovation models could be explored from within Vietnam, Australia and internationally. One excellent example could be the Cooperative Research Centre (CRC) model in Australia that has successfully supported medium to long-term industry-led collaborative research for many years. iMOVE[11] is relevant CRC example. iMove is a leading Australian applied research centre in the transportation and mobility sector. The CRC is a partnership between Government, research institutions and the private sector, iMove helps businesses and government tackle transport-related challenges by connecting and activating the ideas, people, and resources to get things moving.

8.4 Objective 4. Develop a business case and proposal for a larger project: "Linking smallholder farmers to markets: through improved transport infrastructure, logistics and investments in Indonesia and Vietnam"

The project has demonstrated that it is possible to develop and deploy and prototype model of the supply chain of agricultural commodities in Indonesia and Vietnam. This was then used to demonstrate the costs of transport and logistics of the rice supply chain across Indonesia, and then to assess the impacts and costs disruptions caused by natural disasters.

For Vietnam, we have demonstrated the ability to assemble and analysis the movement of commodities from the Son La Province in the north-western mountainous region of Vietnam. This demonstrates the ability to scale to a region and to assess the cumulative impacts of movement of all major commodities from a region and their interactions, specifically identifying bottlenecks and at-risk up-country transport routes. Importantly, the baseline quantified the cost of transport in total and the costs attributed to the different actors along the supply chain where over 60% of the transport costs are borne by the farmer.

The real power of establishing the prototype model and baseline data is in scenario testing, such as changes in production and supply chain, changes in significant infrastructure capacity and/or location, changes in transport technologies, changes in regulation and the impacts of disasters. We were able to compare different investments options, thus allowing informed evidence-based decision making which identify where the benefits accrue across the supply chain. It also allows the private sector to optimise the

[11] https://imoveaustralia.com/

location of collection and processing infrastructure or lobby for improved road access to expand the economic catchment for crop production.

A unique opportunity identified in this project is to explore relationships between transport costs, agricultural market development and livelihoods and poverty, although further analysis is required to quantify the social costs and benefits of road upgrades.

A detailed project proposal for a large ACIAR project was developed with partners and submitted January 2020. The submission was unsuccessful.

The proposals set out the goal to work with industry, government and the private sector to reduce transport logistics' time and costs in priority Indonesian and Vietnamese agricultural supply chains through the following objectives:

1. Creating a platform for a shared understanding of the transport and logistics constraints and ways to improve the movement of goods to markets;
2. Developing and establishing the Transport Network Strategic Investment Tool (TraNSIT) as the tool that allows decision makers from industry and government to identify and quantify bottlenecks and inefficiencies in agriculture supply chains for priority regions and commodities;
3. Working with agribusinesses - including farmers, traders and processors - and government to use TraNSIT outputs to identify optimal logistics and procurement strategies in domestic and export supply chains; and
4. Building local capability to use evidence-based information from TraNSIT to support targeted planning and decision-making on transport and logistics infrastructure and regulation for a number of case study agricultural supply chains.

The technical development and adaptation of the TraNSIT analytical platform to both Indonesia (TraNSIT.id) and Vietnam (TraNSIT.vn), and the establishment of institutional partnerships in both countries would be an outcomes. This follow-on large project would have built on achievements of the previous projects and implement a more focused, longer-term, multi-stakeholder approach that would have identified ways to significantly reduce transport and logistics costs and improve supply chain efficiency and farm-to-market access in a selection of priority agricultural regions and value chains of priority commodities in each country.

The project was to focus on priority "TraNSIT-ready" commodities by location including rice and beef in Indonesia, and pepper and coffee in Vietnam and the relevant modes of transport used. It was to work with in-country organisations to identify an appropriate institutional home within each country, build the skills to incorporate the analyses and insights into decision making. That would allow key partners to use information produced from the project in decisions for infrastructure investments or regulatory change, and to inform better local management of supply chains.

To realise these outcomes, training and mentoring in Indonesia and Vietnam was to be provided to enable partners to understand and collate appropriate data and acquire the knowledge required to map their own supply chains, and understand how to use the information to continue optimising their supply chains.

The project team also planned to engage with relevant private sector entities to ensure the work was pertinent to their key issues, that the project offered a platform for government and industry engagement and that solutions to key industry challenges were examined and reported.

9 Conclusions and recommendations

9.1 Conclusions

There is a critical need for more analytical and evidence-based decision making and policy about transport infrastructure plans and investment options in Vietnam and Indonesia. This study has demonstrated how spatial data analytics and optimisation modelling can be applied to complex, real-life transport investment and planning scenarios at different administrative, investment and operating scales. These applications can directly support institutions and planners to better analyse problems, evaluate options and allocate resources in ways that reduce transport and logistics costs, and improve connectivity for agricultural value chains, smallholder farmers and rural communities.

In both Indonesia and Vietnam, the TraNSIT model and other spatial analytics approaches were adapted and applied to a range of use-cases and scenarios. This provided a proof-of-concept for researchers and stakeholders.

Whilst technically feasible, there are major institutional complexities, capability gaps and resourcing challenges that complicate adoption and integration. These barriers must be addressed in order for these tools and approaches to be realistically and sustainably integrated into an operational analytical and institutional system capable of translating outputs to impacts. Detailed recommendations and solution options have been proposed to address institutional capability gaps, hardware and software gaps and resourcing, and cross-institutional collaboration challenges. The evaluation of innovation models and platforms that promote multi-stakeholder and multi-institutional collaboration in a digital data and spatial analytics hub or cooperative research centre, with a focus on transportation and connectivity could be one important next step.

Below is a summary of key conclusions and recommendations about how spatial analytics and big-data capability could be strengthened and institutionalised in a way to support decision makers and planners.

9.1 Recommendations

Improve strategic alignment for improving decision making and policy in relation to transport infrastructure, market connectivity and digital transformation

Building the decision making capability needed for improved transport infrastructure investment and supporting strategic development remains a very high priority of the Governments of Indonesia and Vietnam, businesses, multilateral development banks (e.g. World Bank) and bilateral donors (e.g. DFAT).

There is also strong alignment between these approaches and strategic priorities identified by the World Bank to support Indonesia's (World Bank, 2015) and Vietnam's (World Bank 2019) integration with global and domestic markets, strengthen, and promote spatial inclusion, along with its resilience.

Build individual and organisational capabilities and structures for collaboration – these are critical to support use (and institutionalisation) of TraNSIT in Vietnam and Indonesia

The institutional landscape associated with transport planning, particularly in rural and agricultural settings, is complex and cross-institutional collaboration is challenging, with high transaction costs. Institutional capability in some key areas is weak and fragmented.

Throughout the course of the project, the ability of relevant agencies and institutions to establish and integrate spatial analytical platforms was constrained by several factors***:***

- fragmented and limited integration of spatial and statistical data and analysis to support decision making within and across institutions;
- limited available expertise in advanced computer programming, spatial analytics, GIS analysis and remote sensing and optimisation modelling within institutions;
- limited use of spatial data processing platforms and innovative analytical tools for big data analysis, optimisation simulation and modelling;
- limited use of, or access to advanced computing and data processing hardware or software, including open source platforms;
- resource and funding constraints;
- limited collaboration and sharing of data and analytical outputs within and between institutions.

These are fundamental challenges that need to be addressed before tools such as TraNSIT can be successfully institutionalised in Indonesia and Vietnam. Multi-lateral development banks such as World Bank and ADB, and bilateral donors and research institutions such as DFAT, JICA and ACIAR play critical roles providing strategic direction, technical assistance, concessional loans, and capability development to support improved transport and logistics infrastructure development and investment. These institutions will need to play an ongoing facilitating and support role in capability development, institutional collaboration and implementing models for digital transformation and innovation to realise the potential.

Consider expanding the analytical focus of the "TraNSIT model" to include spatial analytics and big data applications

The TraNSIT optimisation model demonstrated significant utility for a range of use-cases. However, the project also demonstrated that both relatively simple and more complex statistical and GIS analyses of existing data can provide very useful information and insights for decision makers. There are also significant opportunities for more sophisticated big-data applications.

- A broader focus for Indonesia and Vietnam should be to strengthen capability and application of spatial and GIS data and analytics, optmisation modellling and big-data, rather than just the adaptation and use of the TraNSIT spatial optimisation tool.

Adapt and apply spatial analytics and big-data approaches (including TraNSIT and CVTS analyses) to examine priority transport connectivity issues

There are numerous real-life transport and connectivity challenges affecting planners, decision makers and investors in Vietnam, and this provides an example for similar application in Indonesia. The need for better information exists for Government, industry and private sector stakeholders working at national, provincial and district level scales. Numerous examples and research questions for spatial analytics have been provided in the report. Some of these broader opportunities and scenarios include:

- Provide analytical support to provincial and district level government about road infrastructure planning and investments, both in terms of economic and social rural development.
- Work with industry and lead agribusiness firms to identify bottlenecks and improve product movement efficiency and connectivity in agricultural value chains. Key value chains and regions could include aquaculture, rice and fruit production in the Mekong delta, and coffee, pepper, rubber, fruit and timber production, both nationally and in key production regions
- Provide analytical insights about national-level transport connectivity issues and infrastructure investment options in four interconnected priority areas identified by the Vietnam Development Report (World Bank 2019): (a) integration with global markets,

(b) integration across domestic markets, (c) spatial Inclusion, and (d) building resilience.

- Examine resilience scenarios affecting transport connectivity including impact and responses to natural disasters (flooding, landslides and typhoons), biosecurity pandemics (e.g. COVID-19) and long-term impacts of climate change and variability on national transport movements and supply chain function.
- Identify bottlenecks and evaluate multimodal infrastructure options along major economic road-freight corridors and links with multimodal transport nodes, including congestion around important land-and seaports and terminals.
- Evaluate vehicle and infrastructure upgrading options to reduce energy consumption and greenhouse gas emissions from the transport sector.

In a report to the World Bank Group, titled *Efficient Logistics. A Key to Vietnam's Competitiveness*, Blancas *et al.* (2014) identified the most pressing challenges affecting logistics operations and impacts on domestic and international trade. High amongst the list of challenges, was that *transportation infrastructure projects were planned and executed largely in isolation, without employing a multimodal corridor approach, and with little regard to supply-demand considerations*. This fragmented planning and investment approach they concluded, contributed to a range of reliability bottlenecks, including poor connectivity and congestion between major highways and strategic port and marine terminals, and limited planning and investment in logistics parks that promote clustering of handling, warehousing, transportation, and logistics operations close to gateways, major arteries, and demand centers. A key recommendation was to plan multimodal transport infrastructure using an integrated corridor approach. This is an area where TraNSIT and spatial analytics could directly contribute.

Improve availability and usability of existing statistical and spatial data sets

There is a variety of very useful statistical data and information available from different institutions responsible for data collection and management (e.g., in Indonesia BPS and Satu data Indonesia and in Vietnam GSO, MARD-CIS and TDSI), that with some work, can be used for TraNSIT modelling and other spatial analyses. These data relate to agricultural production, transport networks, value chain function, import-export data, enterprise data, poverty and socio-economic data, and commercial truck and vehicle GPS movement data. However as mentioned above, there are major challenges identifying and accessing data in useful formats for analysis. For example, in Vietnam institutions such as GSO, MARD-CIS, IPSARD, TDSI and NIAPP could explore option to extract and compile key information from individual annual Provincial Statistical Yearbooks and make data for all provinces and districts available online in an electronic database. This would then ensure that data is collected in a consistent manner and provided in a format suitable for statistical summary, analysis and presentation, extraction and analysis. While the importance of these data is universally recognised, to our knowledge, there is no national database where provincial yearbook data is compiled. Nor is the information provided in a database or spreadsheet format enabling easy data extraction, presentation or analysis. In this project, a manual, semi-automated process was needed to extract, compile and clean data from numerous agricultural commodity tables for sixty-three province yearbooks into a single database for analysis.

In the Vietnamese scenarios, commune-level agricultural production data was shown to be extremely useful for a finer granularity of analyses and specific use-cases. Commune-level data can normally only be accessed thorugh personal contacts within Government Departments in each District (sometimes Province). It is often provided as fragmented hard-copy sheet or electronic files. Accessing and compiling commune level data is very time consuming and can only realistically be done for a small number of target districts and communes. Some efficiency and improved utility of the collected data could be achieved by:

- Maintaining an updated and accessible set of **official** geographic files of provincial, district and commune administration boundaries and names (for Vietnam), and in Indonesia for *kabupaten*, *kecamatan* and *desa* scales. Names and unique spatial identifiers should be linked to administration names units in official statistical data sets and regularly updated to enable accurate and efficient geographic presentation and analysis.

Improve and refine TraNSIT model and input dataset functionality and accuracy

The project demonstrated it is technically possible to develop TraNSIT in Indonesia and Vietnam and through the analyses provided valuable insights and evidence to support investment, policy and planning decisions about road and transport infrastructure.

However, there are specific, implementable recommendations to improve TraNSIT and/or potential component datasets:

- Replace the commercial HERE road network currently used, with OSM (Open Street Map) as the main road network data layer.
- Parameterise product and transport flows, movements and transformation processes in more detail, to better reflect the reality and complexity of the value chains in the model.
- Update and refine truck costing data for a larger number of truck types and sizes and obtain estimates about truck overloading rates.
- Develop a methodology to automatically identify the geographic location of commune population centres (e.g., location of commune hall).
- Refine ways to identify the location of key trading, warehousing and processing facilities for specific agricultural value chains (using GSO enterprise data or CVTS data).
- Improve integratation of product imports and export data (volumes, flows and transport mode) through specific land and sea ports.
- Explore ways of incorporating socio-economic impacts and measures into spatial analytics that would support planning to improve road connectivity for poverty reduction and market development in remote rural communities.
- Develop a methodology to estimate commune-level food consumption-demand for for major food categories (based on population and per capita food expenditure and consumption data). Then integrate a national commune-level food consumption data layer into the model. This would enable analysis of supply, demand and distribution of food categories at the commune level.
- Review results and incorporate product and transport flow data from the 2019 TDSI-World Bank survey of nine major freight-commodity sectors into TraNSIT.

Expand web-interface development and use of analytical outputs via TraNSIT web. *Apply TraNSIT and spatial analytics to support decision-making for improving rural road infrastructure and connectivity that reduces rural poverty*

In Son La, TraNSIT analyses were able to identify likely transport bottlenecks, and calculate transport times and cost savings for the different segments and actors along agricultural supply chains (i.e. farm-traders, trader-processors or process-customers). For example, the project showed that investments in new expressways and upgrades to major trunk or arterial roads delivered greater efficiency and cost savings to larger traders, processors and transport operators compared to farmers and traders operating further upstream. An analysis of district road upgrade options showed that upstream actors (e.g. farmers, collectors and smaller traders) incurred greater proportional transport costs, but also received the greater absolute and relative benefits (i.e. reduced transport costs) from upgrades to minor district- and commune-level feeder roads and tracks. It was also possible to identify which geographic areas or communes would be impacted by various infrastructure changes, and those where changes would be negligible. Preliminary analyses also revealed possible correlations between commune travel times and poverty rates.

With further adaption, TraNSIT and other spatial analytics could directly support decision-making for improving rural road infrastructure and connectivity that reduces rural poverty and supports greater market development. These analyses can provide local planners with quantitative insights into how infrastructure investments will impact different communities and supply chain actors.

There is a wealth of evidence and insights from global literature about h*ow* transport affects poor people and the policy implications for poverty reduction. For example, the review by Starkey and Hine (2014) provides strong evidence about how providing basic road connectivity to rural villages can generate significant social and economic benefits. However, they concluded that transport investments tend to benefit the "non-poor" the most, and that investments must be consciously designed to avoid further impoverishing poor people. Starkey and Hine (2014) also found "*the greatest returns to investments (from a range of analyses in China) came from the construction of basic (low-volume) rural roads*". Investments in such roads had a greater influence on poverty reduction and national GDP than investments in better-quality, higher-volume roads. The review also found numerous research studies and several wide-ranging reviews that demonstrated improving rural access led to increased agricultural production, lower costs for farm inputs and lower transport costs for marketed outputs. With specific reference to the Rural Transport Project (RTP1) in Vietnam[12], Mu and van der Walle (2007) concluded that rehabilitation of commune roads to connect them to markets would have vastly larger positive impacts on local poverty if targeted to places with initially lower market development and accompanied by complementary social and economic policies. Again, findings such as these can be integrated into more insightful TraNSIT analyses into potential market development and social impacts for desa in Indonesia and communes in Vietnam under different road upgrading solutions.

Support ongoing collaboration in big-data analytics of Commercial Vehicle Tracking System (CVTS) data in Vietnam[13] and integration with TraNSIT

There are unique opportunities to support ongoing collaboration between CSIRO, the World Bank, the Ministry of Transport (MOT) and other research and private sector partners to provide big-data analytics expertise into the Commercial Vehicle Tracking System (CVTS) data in Vietnam.

The CVTS is a regulatory requirement of the Ministry of Transport (MOT) that collects, transmits and centrally stores GPS locations from over one million commerical freight and passenger vehicles (trucks, buses and cars) in Vietnam. The system is administered by the Vietnam Directorate of Road (DRVN) under the MOT. The vehicle positioning data is captured and warehoused by Hanel, a private technology company under an agreeent with DRVN. As part of the ACIAR and DFAT funded activities in Vietnam, CSIRO has been working with the World Bank (and DRVN and Hanel) to undertake preliminary analyses of CVTS sample data. CSIRO is also participating in a pilot project to access and analyse more recent, very large CVTS data for a range of exploratory big-data use-cases. These may include national road network analytics, origin-destination analytics, port and route congestion cases-studies, COVID-19 transport impact, and supply chain behaviour prediction.

The CVTS is an incredibly unique and rare big-data-set. Access to the data for exploratory analyses under strict use conditions is an equally exceptional opportunity.

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[12] This national Government strategy supports rehabilitation of rural roads with the aim of linking rural and remote commune centers to markets, to stimulate market development and reduce poverty.

[13] The project didn't access big data sets in Indonesia but it is likely similar data are available.

CVTS data has potential to provide deep transformational insights about the performance of the entire national road network, vehicle movements, traffic, congestion, and bottlenecks as well as the movement of freight and products through supply chains on the road transport network.

There is also potential to integrate data outputs from CVTS analytics to strengthen TraNSIT functionality. For example, outputs from CVTS analytics have potential to:

- Provide highly accurate location and performance metrics of the entire road network – including spatial and statistical data of unmapped roads, average segment speeds and dynamics, truck densities and bottlenecks. These empirical data can be integrated into road network layers and TraNSIT truck performance parameters.
- Develop detailed vehicle and product movement maps based on actual truck movements and behaviour. These data can be used to validate and refine the least-cost spatial optimisations in TraNSIT and develop more accurate product and transport flow maps.
- Identify the exact geographic locations of collection, processing, warehousing and distribution facilities of products in agricultural and non-agricultural value chains from truck movements between known identified facilities and nodes (e.g. feed mills, starch factories, ports, logistics and distribution centres)
- Evaluate the impact of road and transport infrastructure developments and or TraNSIT predictions on truck traffic and freight flows and congestion.
- Explore relationships between transport costs, agricultural market development opportunities and potential social and livelihood benefits based on human population, poverty rates and other demographic data.

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11 Appendices

11.1 Appendix 1: Joint CSIRO – TDSI workshop, Hanoi, June 27- 28, 2019

These two workshops and ongoing work were part of the ongoing collaboration and support between the Vietnamese Ministry of Transport and Australian Government through CSIRO, the Australian Centre for International Agricultural Research (ACIAR) and the Australian Department of Foreign Affairs and Trade (DFAT).

The first workshop - Strengthening Transport Infrastructure Policy and Planning Capability in Vietnam by Digital and GIS Innovations – provided a forum for 45 participants from agencies and organisations such as Ministry of Transport, TDSI, CSIRO, AECOM, DFAT, World Bank, NOMAFSI, ACIAR, CASRAD, VAST, MARD-CIS, IPSARD, GSO and ADB).

The workshop purpose was to:

- Provide an overview of current transport planning practices and strategies;
- Provide an overview of digital and GIS Innovations in transport planning; and
- Explore opportunities for data and knowledge sharing and collaboration in ongoing work.

The second workshop - Adapting and integrating TraNSIT into transport decision making and planning in Vietnam - allowed a subset (20 participants) to

- Discuss options and concrete next steps needed to adapt and integrate TraNSIT into TSDI transport decision making and planning in Vietnam.
- Discuss current situation, options, gaps and priority next steps for data, hardware and software, capability and institutionalizing in TDSI, data access and sharing arrangements with GSO, MARD-CIS and others.
- Identify and progress scenarios, scenarios, and next steps for DFAT and ACIAR projects, including TDSI involvement.
- Review and refine a proposal for Aus4Transport funding.

These workshops were an important step in progressing the collaboration between TDSI, CSIRO, Australia (through DFAT and ACIAR) and other partners in developing systems and capability in transport infrastructure decision making and planning in Vietnam.

The workshop agendas are provided below.

Workshop 1:

Strengthening Transport Infrastructure Policy and Planning Capability in Vietnam by Digital and GIS Innovations

Day 1 - Thursday 27th June 2019,

Pan Pacific Hotel

1 Thanh Niên, Trúc Bạch, Hà Nội

Workshop purpose

1. Provide an overview of current transport planning practices and strategies;
2. Provide an overview of digital and GIS Innovations in transport planning; and
3. Explore opportunities for data and knowledge sharing and collaboration in ongoing work.

8:00 – 8:30	**Arrival and registration**	**30 min**
8:30 – 8:40	**Welcome and introduction** TDSI and CSIRO	10 min
8:40 – 8:55	**Aus4Transport – Supporting development of Vietnam's high quality transport infrastructure** DFAT-AECOM	15 min
8:55 – 9:55	**Session 1 – Transport Planning in Vietnam: Current Practices**	**60 min**
	Introduction of Vietnam transportation network Transport Planning and Strategy, TDSI	15 min
	National transport strategy and planning: methodology and process Transport Planning and Strategy - Transport Demand Forecast and Traffic Management, TDSI	30 min
	Discussion	15 min
9:55 - 10:25	**Group Photo - Tea break**	30 min
10:25 - 2:00	**Session 2 – Application of digital and GIS Innovations in transport planning**	**95 min**
	Digital and GIS innovations in World Bank studies and projects for transport sector development - Understanding trade and transport connectivity through GIS	30 min

	- Mapping truck flows using GPS data - Going geospatial with road asset management system - Analyzing criticality and vulnerability to climate/disaster risks of multi-modal transport network in Vietnam Jen JungEun Oh, Senior Transport Economist	
	CSIRO Transport Network Strategic Investment Tool (TraNSIT): - Transport logistics and infrastructure decision making in Australia. Dr. Chris Chilcott, CSIRO - Early insights from adapting to Indonesia and Vietnam Dr. Steve McFallan and Caroline Bruce, CSIRO	30 min
	Transport issues in selected agricultural supply chains in Vietnam Ms. Phan Tho, CASRAD	15 min
	Logistics constraints in fruit and vegetable value chains in Vietnam Dr. Nguyen Anh Phong. IPSARD	15 min
	Questions	5 min
12:00 – 13:00	**Lunch**	
13:00 – 13:20	**Discussion (Session 2)**	20min
13:20 – 14:50	**Session 3 – Opportunities for data and knowledge sharing and collaboration**	**90 min**
	Vietnam Transportation Database System Traffic Safety Database Centre, TDSI	15 min
	Vietnam Logistics Statistical System Depocen	15 min
	Group discussion	60 min
14:50 – 15:15	**Tea Break**	20 min
15:15 – 16:15	**Group discussion and next steps**	60 min
16:15	**Finish**	

Workshop 2:

Adapting and integrating TraNSIT into transport decision making and planning in Vietnam

Day 2 – Friday 28th June 2019

Pan Pacific Hotel

1 Thanh Niên, Trúc Bạch, Hà Nội

Workshop purpose

1. Discuss options and concrete next steps needed to adapt and integrate TraNSIT into TSDI transport decision making and planning in Vietnam

2. Discuss current situation, options, gaps and priority next steps for data, hardware and software, capability and institutionalizing in TDSI, data access and sharing arrangements with GSO, MARD-CIS and others.

3. Identify and progress scenarios, case studies and next steps for the project, including TDSI involvement;

4. Review and refine the A4T concept proposal

8:00 – 8:30	**Arrival and registration**	**30 min**
8:30 – 8:35	**Welcome and introduction** TDSI and CSIRO	5 min
8:35 – 9:55	**Session 1**	**60 min**
	Reflection on Day 1 workshop – important insights, challenges, issues and opportunities, gaps (30 min) Facilitated discussion. FGG	30 min
	What functionality, and capability does TDSI need and want from a spatial GIS based transport analytical platform? TDSI – Discussion	15 min
	Session 2a	**60 min**
	Adapting TraNSIT.VN and integrating into TDSI - options and next steps CSIRO	15 min
	Data – stocktake of data options and needs, current, gaps and priorities, next steps (45 min)	30 min
	Discussions with GSO and MARD- CIS about ongoing data sharing and integration – procedures and possibilites	15 min
10:30 - 11:00	**Tea break**	30 min
	Session 2a	**60 min**

11:00 - 12:30	**Hardware and software** – identify options and needs, current, gaps and priorities, next steps	15 min
	Capacity – identify current, gaps and priorities and collaborating researchers, next steps	15 min
	User interface and hosting – discuss options, next steps	15 min
	Next steps for establishing a partnership and data sharing agreements	15 min
	Session 3. – Overview - **Scenarios, next steps and work plans for ACIAR and DFAT projects** - **A4T Concept proposal**	**30 min**
12:30 – 13:30	**Lunch**	**60 min**
13:30 – 15:00	**Session 3 contd.**	**90 min**
	- **ACIAR project and DFAT projects** - **A4T proposal concept**	70 min
	Update on working group progress	20 min
15:00 – 15:30	**Afternoon tea**	30 min
15:30 – 17:00	- **ACIAR project and DFAT projects** - **A4T proposal concept**	90 min
17:00 – 17:30	- **Final progress summary and actions**	30 min

11.2 Appendix 2: Factsheets

11.2.1 Indonesia

Transport Network Strategic Investment Tool (TraNSIT)

Enhancing smallholder linkages to markets by optimising transport and logistics infrastructure

Transport infrastructure is essential for moving produce from 57 million hectares of Indonesian agricultural and horticultural land annually. Sea and land transport distances can be extensive, often with 100's of kilometres from the farm to market. Targeted investment in infrastructure and regulatory changes can significantly reduce logistics costs to farmers and increase access to markets. Understanding the impact of changes to supply chain flows and transport costs from farm to market will be critical to optimising value to farmers from the investment options available.

What is TraNSIT?

The Transport Network Strategic Investment Tool (TraNSIT) is a modeling tool that provides an evidence-based approach to identify large and small-scale infrastructure investment, and reduce logistic costs to farmers and other enterprises in the supply chain. Since getting products from farm to market where transport networks are unreliable and a major barrier to agricultural development, TraNSIT can be applied to improve transportation aspects that can better promote more efficient and inclusive market linkages.

TraNSIT in Australia

Agriculture supply chains in Australia are often characterised by transport distances of over 1000km between production and markets, with transport costs accounting for up to 40% of the market price. To provide a comprehensive view of transport logistics costs and benefits due to infrastructure investments and regulatory changes in agriculture supply chains, the Australian Government engaged its science agency, the CSIRO, to develop the Transport Network Strategic Investment Tool (TraNSIT). TraNSIT has been applied to all Australian agricultural commodities, representing more than five million vehicles and 10,000 rail trips per annum. It is currently being used in Australia by all levels of government to prioritise transport related logistics investments. It has recently been used to prioritise $100 million of government investment in roads across northern Australia. It is currently being used to plan improvements to rail/road storage, access to ports and to reduce bottlenecks to livestock export.

Benefits of TraNSIT

- Analysing the impact of road upgrades such as sealing, bridge upgrades, axel load upgrades, first improvements from farm storage and markets;
- Analysing upcountry storage, packing or centralised warehousing options that improves the efficient utilisation of both farmer and transport provider vehicles;
- Analysing impacts of vehicle improvements or new trucking fleets;
- Optimising farming supply chains to state owned storage and processing enterprises, as well as to markets;

- Identifying solutions to logistical bottlenecks between paddock and market for remote, small-scale farmers that impact both transport efficiency and food losses;
- Testing regulatory changes.

Developing TraNSIT in Indonesia

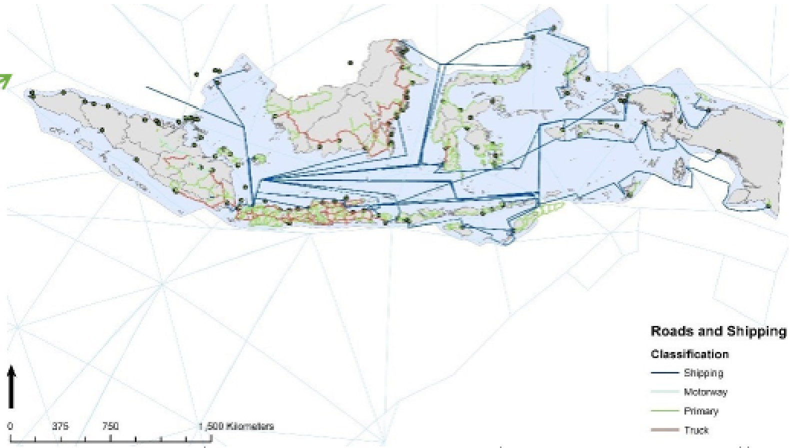
CSIRO and the Australian Government has approached the Indonesian Government, State Owned Enterprises, Industry Associations and Companies to extend TraNSIT to Indonesian agriculture and other commodities, with initial case studies in cattle, rice and sugar. TraNSIT utilises best available data on agriculture production (tonnes and area) within each case study area, supply chain paths and a road/shipping network. Over the next 3-5 years, a version of TraNSIT will be developed for use within Indonesia. The figure below highlights some of the components of TraNSIT Indonesia.

Network
- Roads and features
- Shipping lines
- Rail lines and load points

Vehicles and ships
- Costs model
- Optimal vehicle selection

Commodities
- Enterprise locations
- Demands or supplies

Calculation
- Vehicle route optimization
- Congestion



	Modelled cost (Rp/km) per travel speed – sealed roads			Modelled cost (Rp/km)– unsealed roads	
Type	100 km/h	60 km/h	20km/h	60 km/h	20km/h
Suzuki Carry	2,988	3,363	5,915	3,525	6,301
Colt Diesel	4,960	5,389	8,647	5,686	9,302
8 Tonne Fuso	6,806	7,308	11,298	7,768	13,162
Semi-Trailer	9,839	10,428	16,390	11,380	18,984

Australian Government
Australian Centre for International Agricultural Research

CSIRO TraNSIT

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11.2.2 Vietnam

Transport Network Strategic Investment Tool (TraNSIT)

Unlocking infrastructure investment and regulatory options for efficient logistics in Vietnamese agriculture, horticulture and forestry

Transport infrastructure is essential for moving produce from 10 million hectares of Vietnamese agricultural land annually. The vast majority of production is from smallholders with farms less than 2 ha, and access to market is critical to sustaining livelihoods and ensuring food security. Changes in consumers' demand towards animal products, fruit, vegetables and processed foods will see expansion in intensive production and a need to improve logistics and cold chain management. Targeted investment in infrastructure and strategic regulatory changes can substantially reduce logistics costs across the supply chain. Understanding the impact of changes to supply chain flows and transport costs across all enterprises will be critical to optimising value from the investment options available.

What is TraNSIT?

The Australian Government engaged its science agency, the CSIRO, to develop the Transport Network Strategic Investment Tool (TraNSIT) to provide a comprehensive view of transport logistics costs and benefits due to infrastructure investments and regulatory changes in agriculture supply chains. TraNSIT optimises transport routes and vehicle selections for enterprises and vehicle/rail trips between enterprises and their domestic and export markets, providing valuable input into operational and investment decisions.

TraNSIT in Australia

TraNSIT has been applied to most Australian agricultural commodities, representing more than 5 million vehicle and 10,000 rail trips per annum between hundreds of thousands of enterprises. It is currently being used in Australia by all levels of government to prioritise transport-related logistics investments. It was recently used to prioritise $100 million of government investment in roads across northern Australia and is currently being used to plan improvements to rail/road storage, access to ports and to reduce bottlenecks to livestock export.

TraNSIT in Vietnam

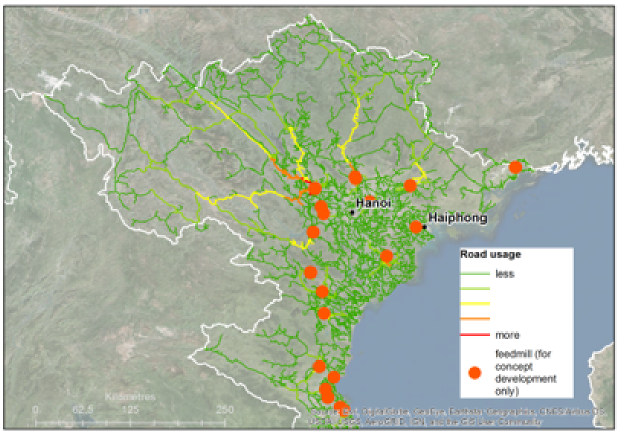
CSIRO is working with the Vietnamese Government and research partners to extend TraNSIT to Vietnamese agriculture and other commodities. Initial case studies in the North West Highlands examined the cassava and maize supply chain from farms to feed mills. Future work will extend to a broader range of commodities and compare results at different scales (commune, district, province) across parts of the country. We will also consider fruit and vegetable supply chains into Hanoi; commodity export supply chains such as rice, tea, coffee, fish and prawns; and the development of agri-industrial clusters. A version of the tool will be developed for use within Vietnam. TraNSIT utilises best available data on agriculture production (tonnage and location) within each province, district or commune, supply chain paths and a road/shipping network. The figure below highlights some of the input and output components of TraNSIT applied to Vietnam.

Network
- Roads and features
- Shipping lines
- Rail lines and load points

Vehicles, trains and ships
- Costs model
- Optimal vehicle selection

Commodities
- Enterprise locations
- Demands or supplies

Calculation
- Vehicle route optimisation
- congestion



	Modelled cost (VND/km) per travel speed – sealed roads			Modelled cost (VND/km)– unsealed roads	
Type	100 km/h	60 km/h	20km/h	60 km/h	20km/h
Small truck (1 tonne)	4,930	5,550	9,760	5,810	10,390
Small truck (2 tonne)	8,180	8,900	14,260	9,380	15,340
Medium truck (8 Tonne)	11,320	12,060	18,640	12,810	21,710
Large truck (20 Tonne)	15,480	17,200	27,040	18,780	31,310

Applications of TraNSIT to reduce costs of transport in Vietnam include:

- Analysing the impact of road upgrades such as sealing, bridge upgrades, axel load upgrades, first/last mile improvements to processing, storage and port;
- Analysing storage or centralised warehousing that improves the efficient utilisation of different vehicle sizes, transport between provinces and shipping;
- Analysing impacts of vehicle improvements or new trucking fleets;
- Optimising supply chains for state owned enterprises or the development of agri-industrial clusters from farms to processing as well as to storage and markets;
- Identifying solutions to logistical bottlenecks between paddock and market for remote, small-scale farmers;
- Optimising integrated road and shipping;
- Testing regulatory changes such road pricing, tolls.

Australian Government
Department of Foreign Affairs and Trade

Australian Government
Australian Centre for International Agricultural Research

TraNSIT

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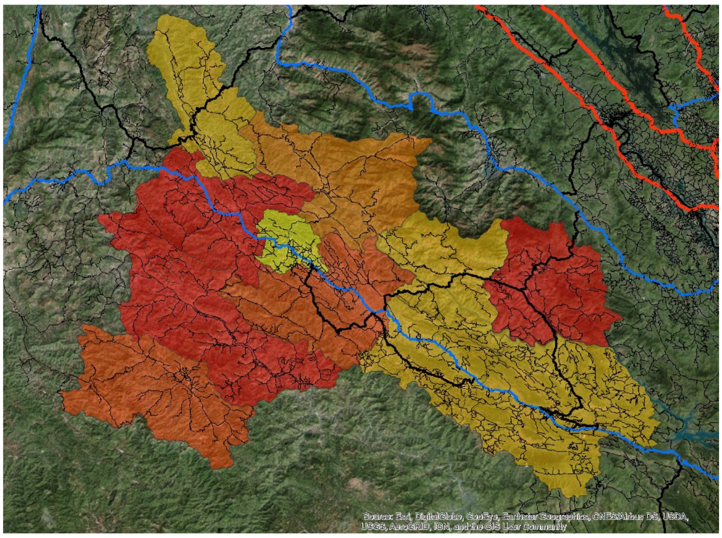
11.3 Appendix 3: Key datasets used in project – Vietnam

DATASET	DETAILS

Agricultural production data – district	- Original source: 2018 Son La Statistical Yearbook
	- Attributes:
	    o District-level data for all of Vietnam
	    o All agricultural commodities
	- Currency: 2018
	- Processing undertaken in project: Cleaned/standardised, converted to spatial format (cassava, maize, sugar, coffee)

Sample of district-level production data (rice) with roads overlay, for Son La Province

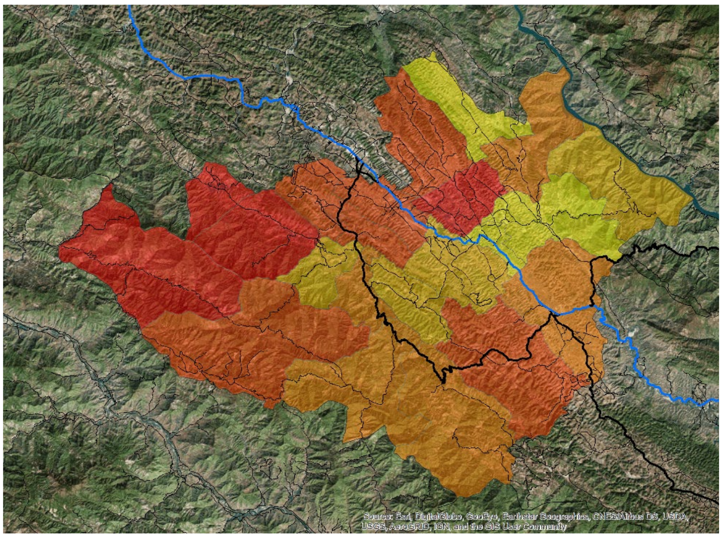


DATASET	DETAILS

Agricultural production data – commune	- Original source: Moc Chau and Mai Son District governments
	- Attributes:
	    o Commune-level data for Moc Chau and Mai Son
	    o All agricultural commodities
	- Currency: 2018
	- Processing undertaken in project: converted to spatial format (cassava, maize, sugar, coffee, vegetables).

DATASET	DETAILS

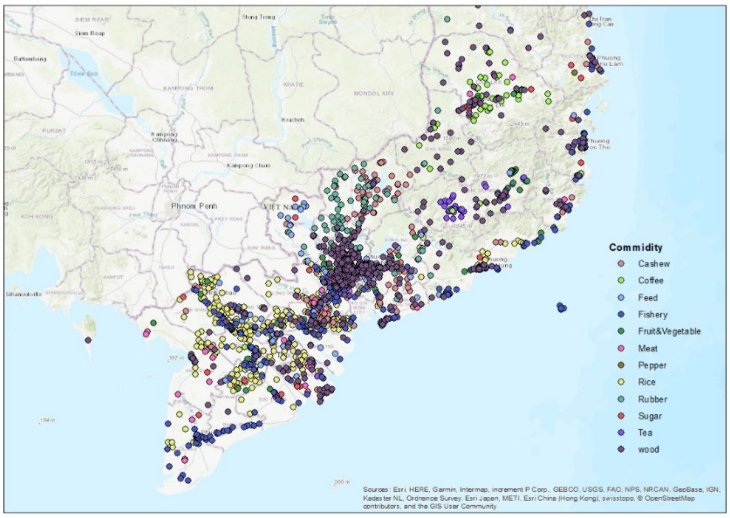
Sample of commune-level production data (rice) with roads overlay, for Mai Son District



DATASET	DETAILS

Agro-enterprise data	- Original source: General Statistics Office (GSO), expert knowledge by NOMAFSI
	- Attributes:
	    o an extremely detailed database of information for ~6000 enterprises across Vietnam
	    o agricultural commodities only
	- Currency: 2011/12 and some 2018 updates
	- Processing undertaken in project: geocoded, translated, gaps identified and filled by NOMAFSI for select commodities in Son La Province

Sample of enterprise dataset, southern Vietnam



DATASET	DETAILS

Import/export volume data and statistics	- Original source: General Department of Vietnam Customs (GDVC)
	- Attributes:
	    o Both import and export data across Vietnam (USD or tonnes)
	    o agriculture and freight
	    o seaports, road and airports
	- Currency: 2018
	- Processing undertaken in project: geocoded

DATASET	DETAILS

Sample from customs dataset

TỔNG CỤC HẢI QUAN
CỤC CNTT & THỐNG KÊ HẢI QUAN

Phụ lục I :

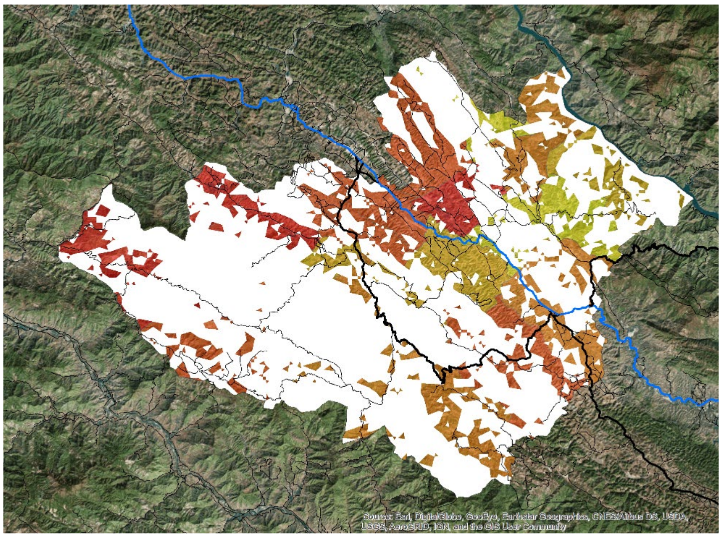
(Đính kèm Công văn số /CNTT-TK ngày /11/2019 của Cục CNTT & TKHQ)

Cửa khẩu	Nhóm hàng chính	ĐVT	Lượng	Trị giá USD
CK Bắc Phong Sinh (Quảng Ninh)	Sản phẩm từ cao su	USD	-	26,049
	Máy vi tính, sản phẩm điện tử và linh kiện	USD	-	586,532
	Xe máy và linh kiện, phụ tùng	USD	-	280,391
	Vải các loại	USD	-	1,291,654
	Thủy tinh và các sản phẩm từ thủy tinh	USD	-	36,601
	Sản phẩm từ sắt thép	USD	-	560,221
	Sản phẩm từ kim loại thường khác	USD	-	4,068
	Sản phẩm từ chất dẻo	USD	-	317,020
	Sản phẩm hóa chất	USD	-	67,541
	Phương tiện vận tải khác và phụ tùng	USD	-	25,008
	Nguyên phụ liệu dệt, may, da, giày	USD	-	590,913
	Hàng điện gia dụng và linh kiện	USD	-	25,145
	Chất dẻo nguyên liệu	Tấn	9	10,320
	Dây điện và dây cáp điện	USD	-	13,636

DATASET	DETAILS

Classification of cultivated agricultural land	- Original source: European Space Agency Global Landcover dataset
	- Attributes:
	  o 300m grid
	  o annual global land cover time series from 1992 to 2015
	  o includes categories for cropped (irrigated/non-irrigated) v. non-cropped land
	- Currency: 2015
	- Processing undertaken in project: separated out cropped land class, converted to shapefile. Used as a mask to determine location of farmed areas (production locations) across landscape

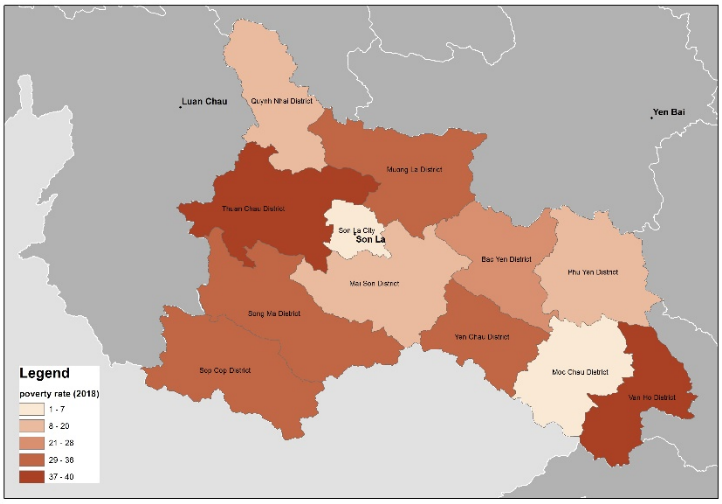
Sample of cropped v. non-cropped (white) land as extracted and re-sampled from global landcover dataset, with commune-level production data (rice) underlay and roads overlay, for Mai Son District



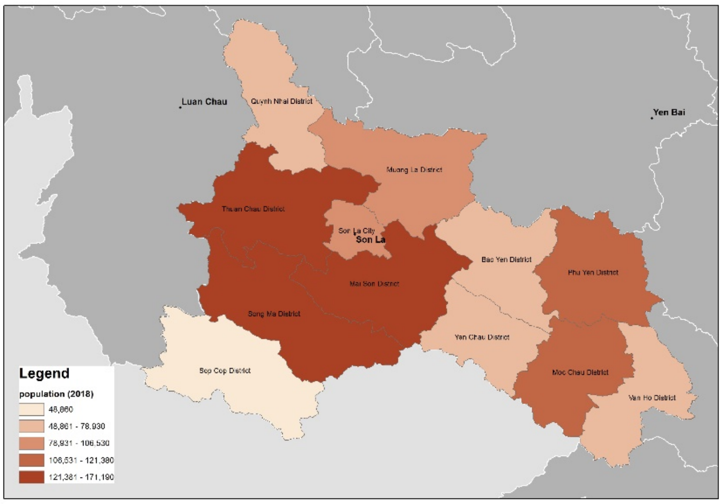
Human population, density and poverty data by district	- Original source: GSO - Attributes: o Human population, density and poverty data - Currency: 2018 - Processing undertaken in project: none required

Sample of poverty data (rate) per district, for Son La Province

DATASET	DETAILS



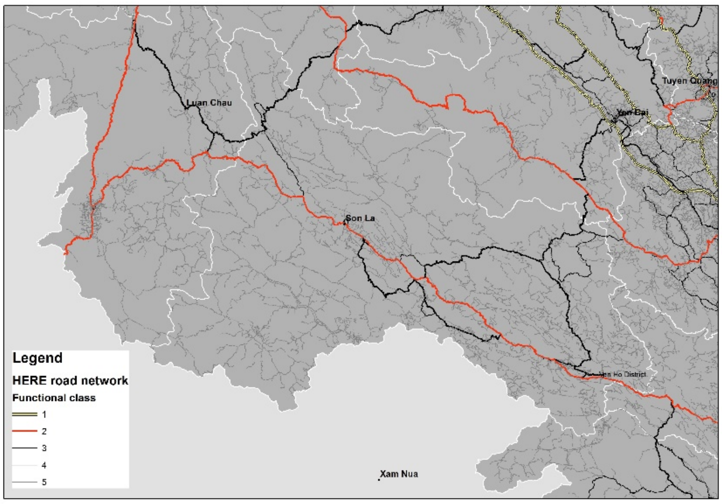
Sample of population data per district, for Son La Province



road network	- Original source: Navigate for HERE network, Web (https://www.openstreetmap.org/#map=5/-28.153/133.275) for Open Street Maps (OSM) network
	- Attributes:
	    o HERE network: line layer represents streets, highways, roads, ramps, and ferries. This dataset includes all navigable links, with their attribution relevant for route calculation and route guidance.
	    o OSM network: refer https://wiki.openstreetmap.org/wiki/Map_features
	- Currency: 2018 for HERE network, various for OSM (continuously updated)
	- Processing undertaken in project: none required

Sample of roads data, for Son La Province

DATASET	DETAILS



Truck operating cost data	- Original source: Yin Yin Lam, Kaushik Sriram and Navdha Khera (2019) Strengthening Vietnam's Trucking Sector. Towards Lower Logistics Costs and Greenhouse Gas Emissions. World Bank Group
Commercial Vehicle Tracking System (CVTS) data	- Original source: collected for the Directorate of Roads of Vietnam (DRVN) - Attributes: o GPS tracers of all commercial vehicles in Vietnam for 1 – 10 August, 2017 - Currency: August 2017 - Processing undertaken in project: Trucks only were filtered out, GPS points map-matched to road network. Data was used to calculate average speeds for road segments

Sample of CVTS data, showing GPS locations for commercial vehicles

Product flow and transport maps of key commodity	- Original source: based on published reports, secondary sources and interviews with key informants - Attributes: o Product flow maps and transport information

DATASET	DETAILS
supply chains, Son La Province	○ Cassava, maize, sugar, coffee and vegetable supply chains - Currency: 2017 - current - Processing undertaken in project: Data and flows within the maps were used to inform transport modelling

Diagram of the cassava supply chain in Son La Province

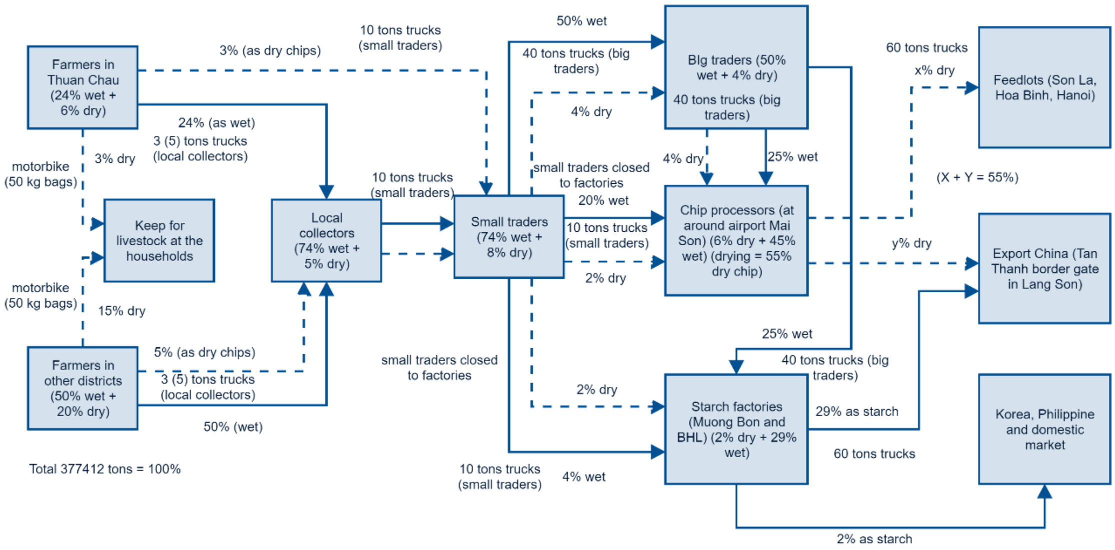


Diagram of the maize supply chain in Son La Province

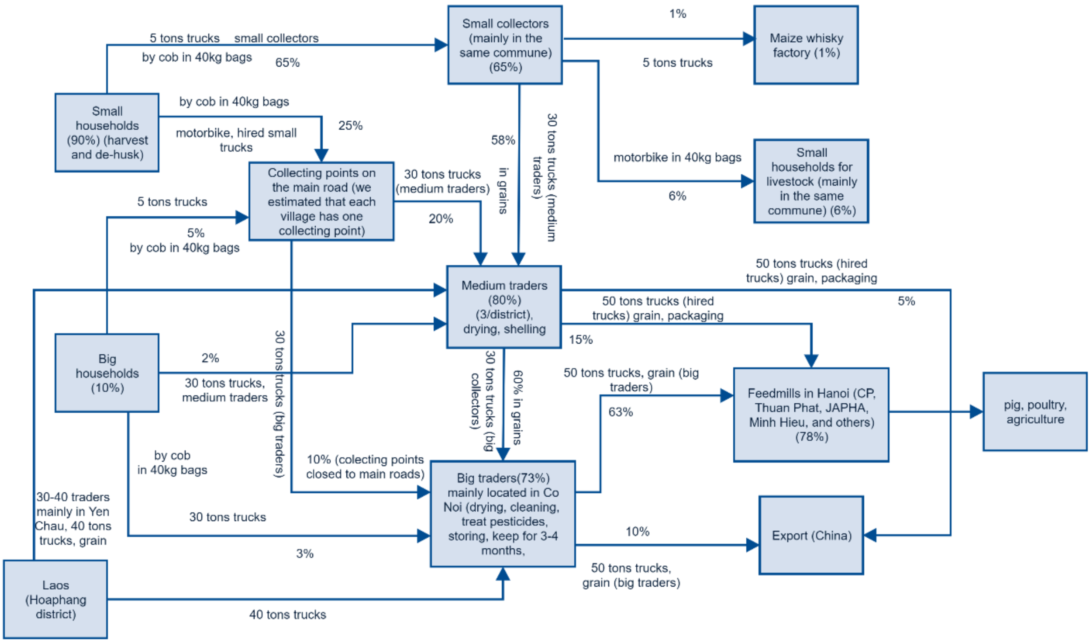


Diagram of the sugar supply chain in Son La Province

DATASET	DETAILS

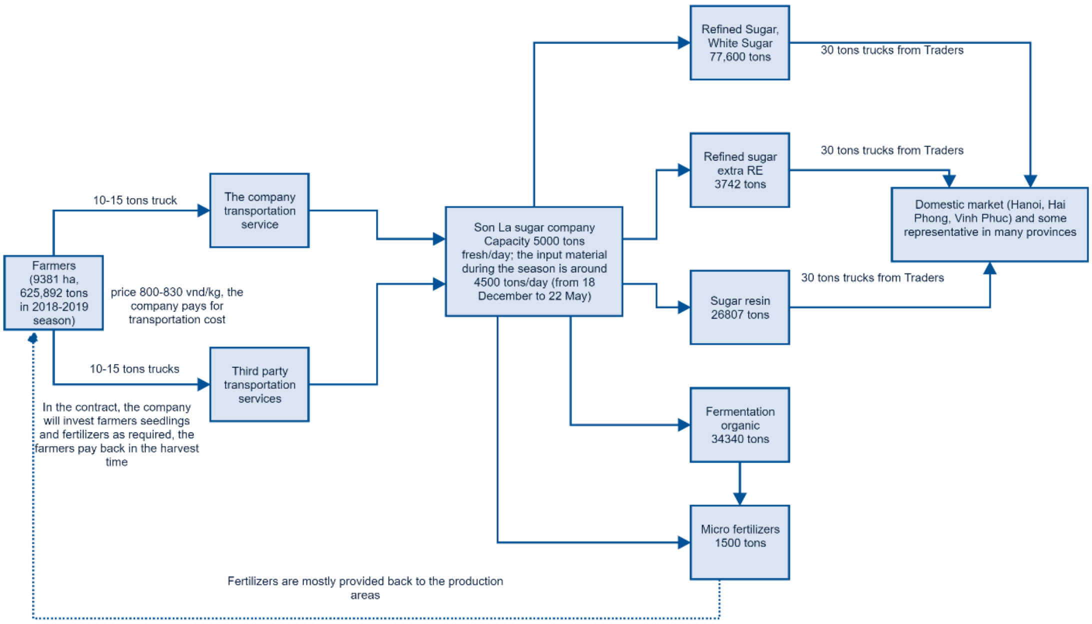
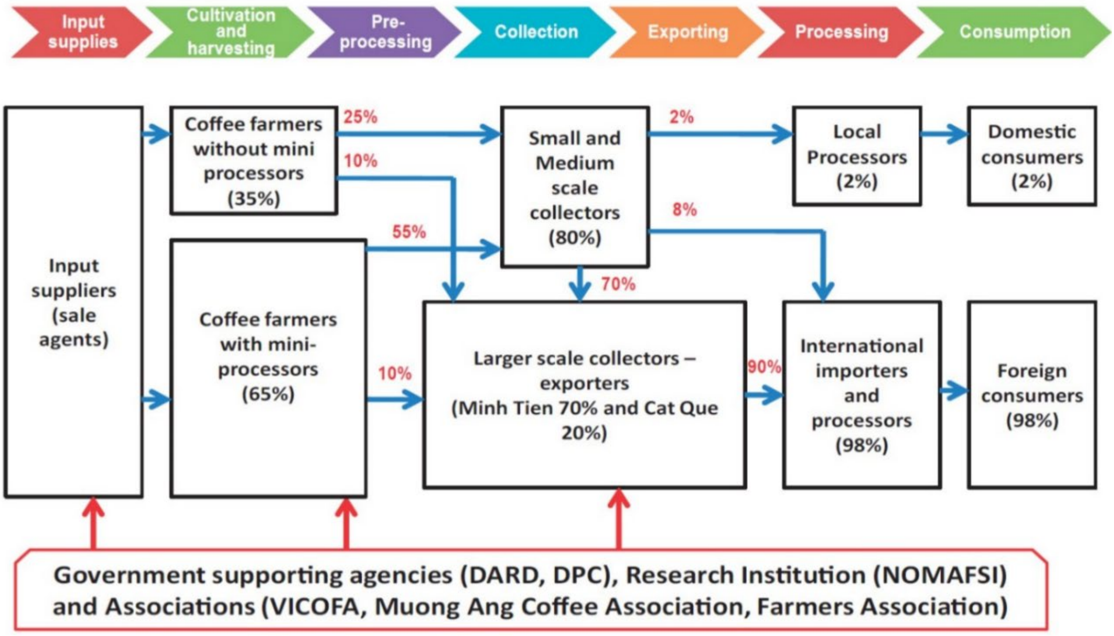
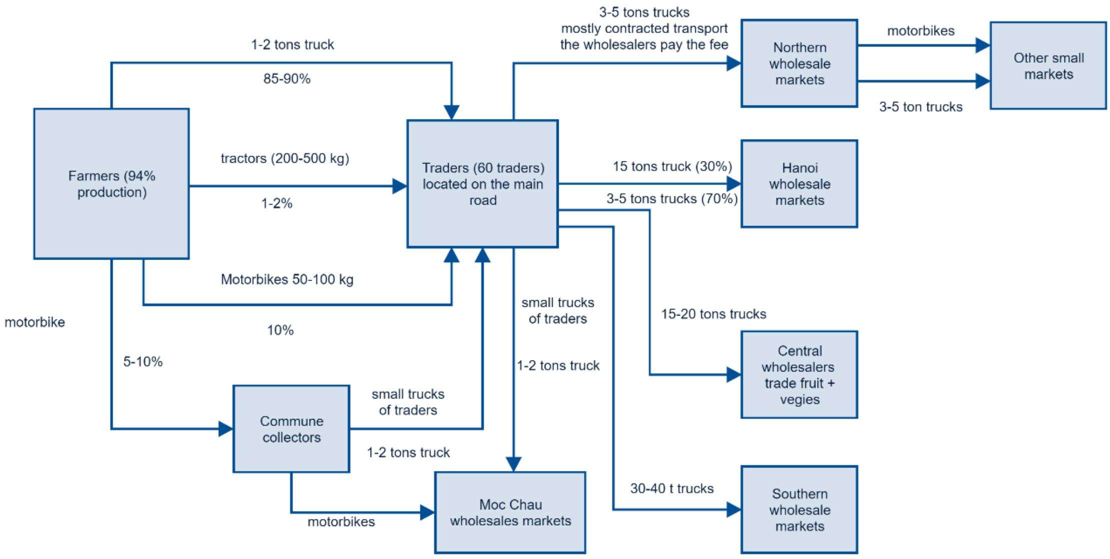


Diagram of the coffee supply chain in northern Vietnam (FAO, 2015)



DATASET	DETAILS

Diagram of the vegetable supply chain in Moc Chau District (source: FAO, 2015)



11.4 Appendix 4: Additional model outputs - Vietnam

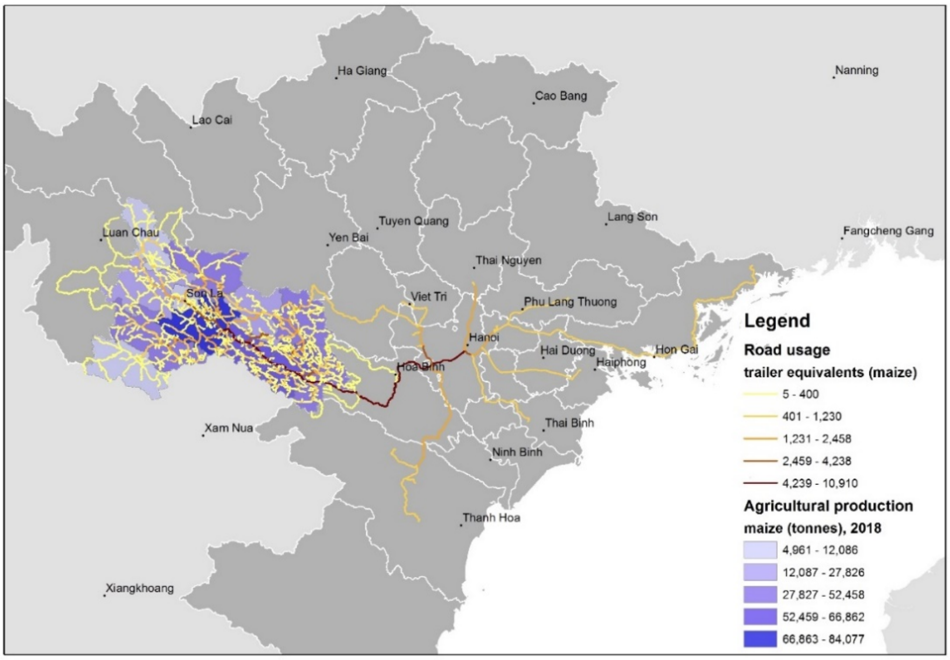


Figure 11.1 Maize production and road usage for the maize supply chain

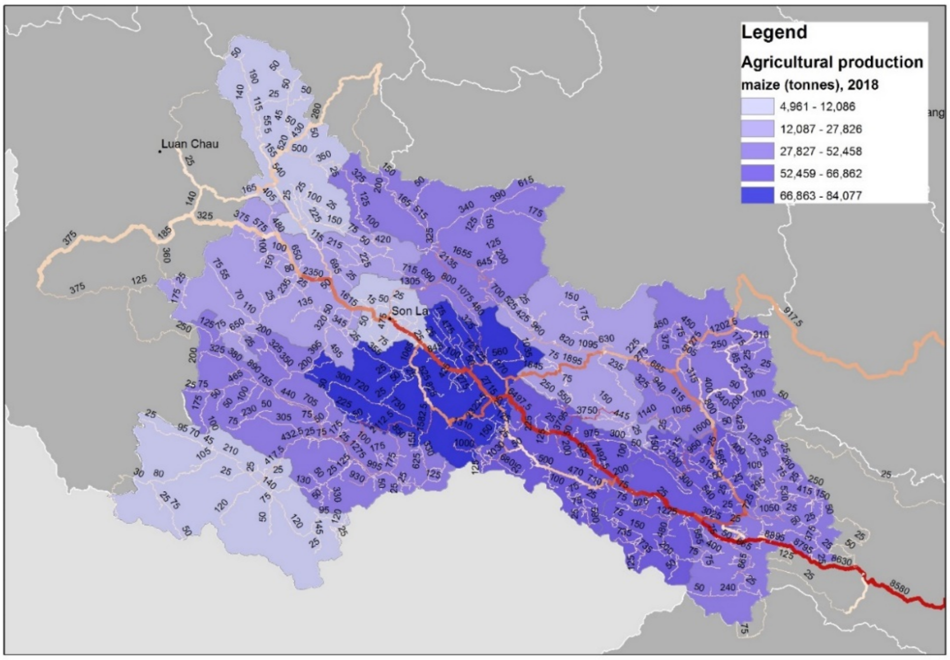


Figure 11.2 Maize production and road usage for maize supply chain, Son La Province

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

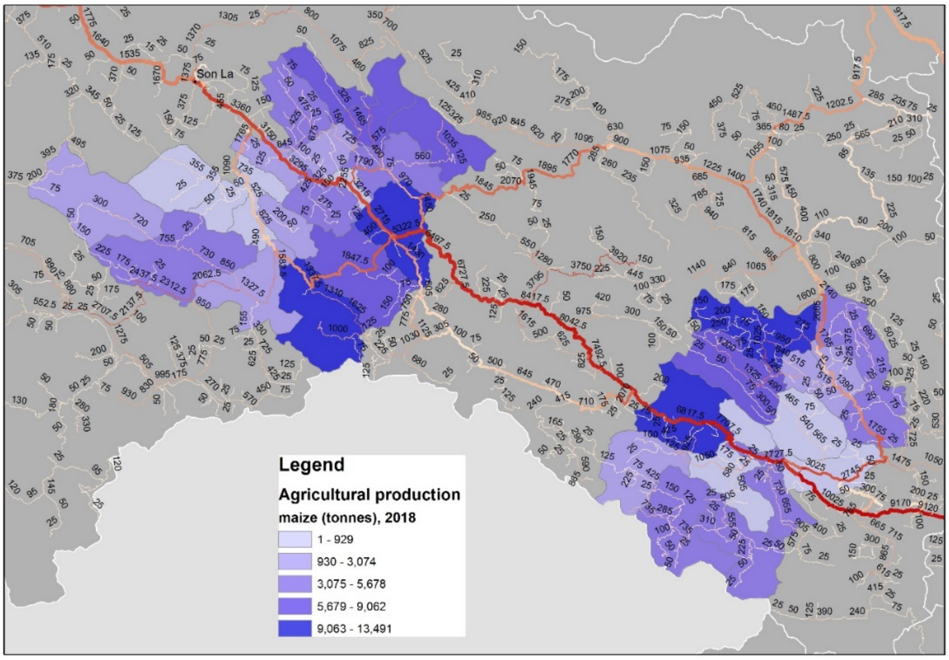


Figure 11.3 Maize production and road usage for maize supply chain, Mai Son and Moc Chau districts

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

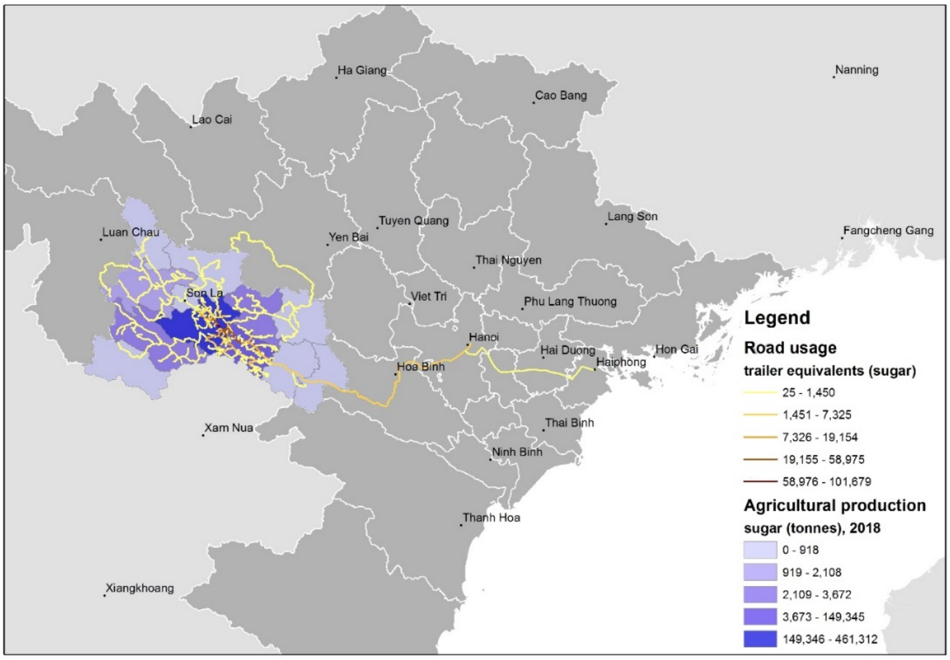


Figure 11.4 Sugar production and road usage for the sugar supply chain

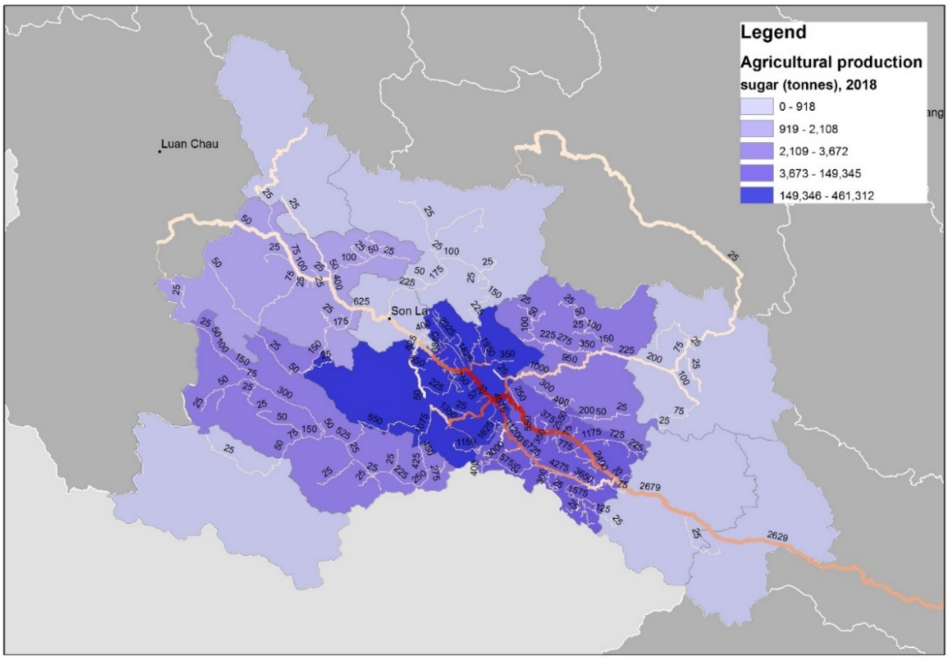


Figure 11.5 Sugar production and road usage for sugar supply chain, Son La Province

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

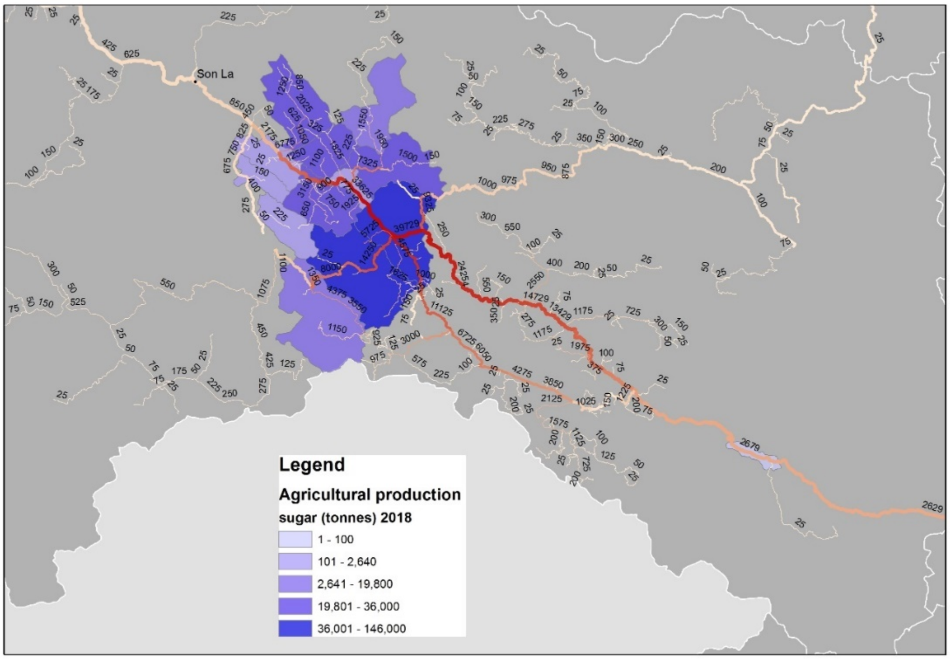


Figure 11.6 Sugar production and road usage for sugar supply chain, Mai Son and Moc Chau districts

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

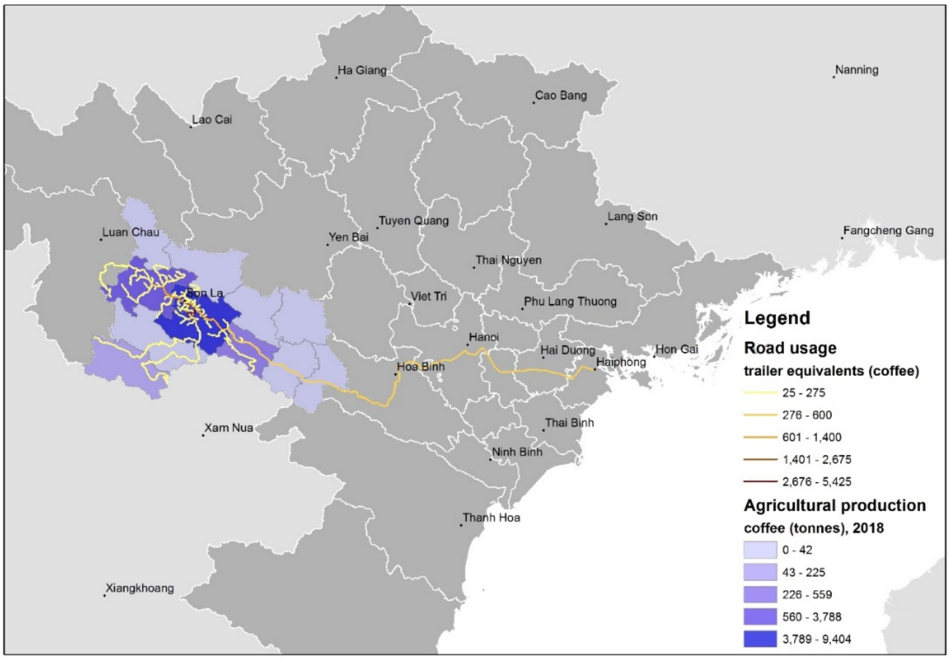


Figure 11.7 Coffee production and road usage for the coffee supply chain

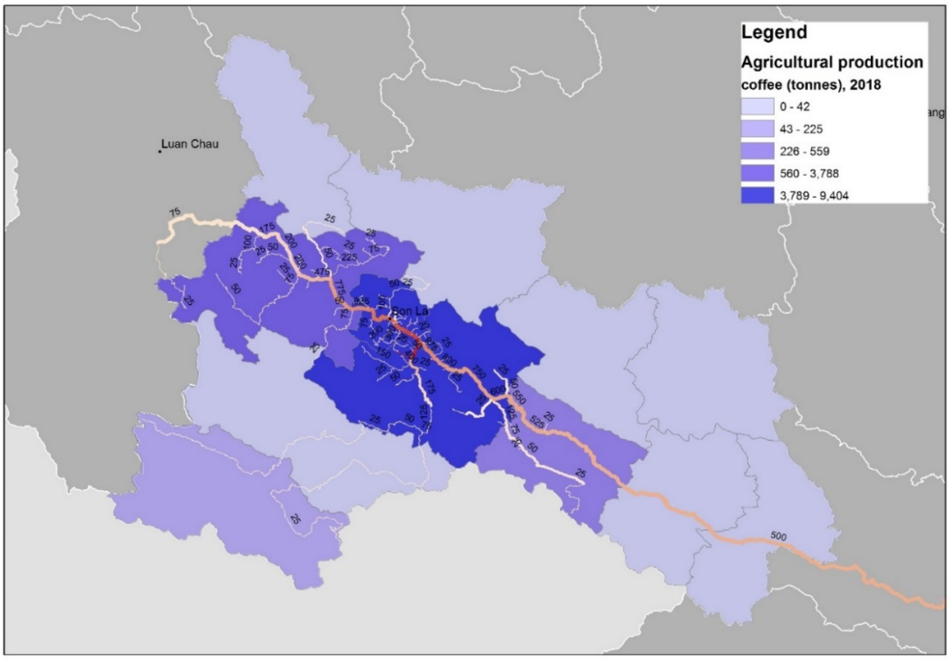


Figure 11.8 Coffee production and road usage for coffee supply chain, Son La Province

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)

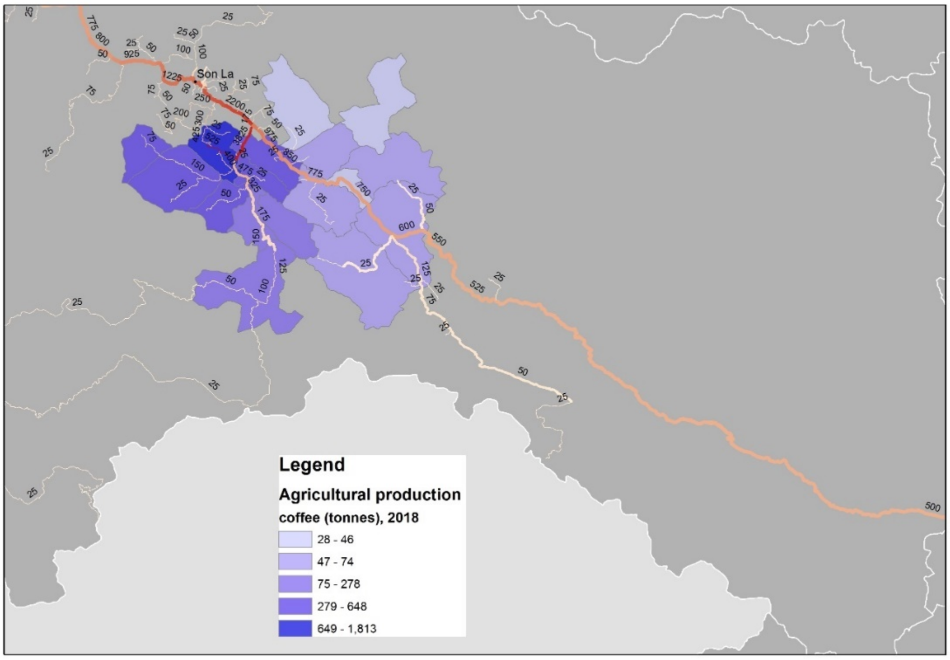


Figure 11.9 Coffee production and road usage for coffee supply chain, Mai Son and Moc Chau districts

Note: line colour shows density of usage for different road classes: light usage (pale pink) -> heavier usage (dark red); line thickness shows road type: major roads (thick) -> minor roads (thin)