VKT and GHG emissions baseline report – a research note

Progressing the Te Puna Taiao environmental impact initiative for land transport

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Executive summary

New Zealand Government has committed to reaching net zero emissions of long-lived gases by 2050. The Government has set four transport targets in the latest Emission Reduction Plan (ERP) that will support reducing transport emissions. The first national target requires total vehicle kilometres travelled (VKT) from the light fleet to reduce by 20% by 2035 in part through improved urban form and providing better travel options, particularly in our largest cities. Achieving this target would mean that national light vehicle VKT in 2035 should be about the same as it was in 2019, in spite of expected changes in population and economic growth. The globally unique national VKT reduction approach not only addresses GHG emissions but also realises multiple societal benefits. The ERP indicates that specific VKT-reduction targets for major urban environments will also be set by the end of 2022, to guide progress towards this national target.

To enable prediction of impacts and inform the actions required, Beca Ltd has been commissioned by Waka Kotahi NZ Transport Agency (Waka Kotahi) as part of its Te Puna Taiao initiative to undertake research to develop subnational baseline VKT and greenhouse gas (GHG) emissions for urban environments for the years 2019, 2025, 2030 and 2035. It is to provide consistency across urban environments and a clear point of reference to be used for climate impact policy assessment primarily at a strategic systems level while being useful to business case development and evaluation and environmental permitting.

Therefore, for the purpose of this research, we have defined baseline as the business-as-usual scenario. This assumes no new transport interventions would take place to promote mode shift. This research was guided by a technical steering group comprising Waka Kotahi and MoT specialists.

A literature review was carried out to understand emission reduction targets and provide context to this report. In the National Policy Statement on Urban Development (NPS-UD) and ERP, the reduction initiatives target five Tier 1 and eight Tier 2 urban environments.

The review of available datasets and research suggests that at a national level, Ministry of Transport (MoT) and Waka Kotahi have built reliable VKT estimates observed from odometer readings and future projections using econometric models. However, the datasets available for model building at a subnational level vary in their temporal continuity (eg census years only vs. quarterly from 2002), granularity (eg link level vs. regional level) and spatial coverage (eg nation-wide vs. urban environments only).

The focus of this research is to create a consistent approach for distributing the national level light vehicle VKT and GHG emissions estimates across subnational regions defined around the Tier 1 and 2 urban environments, with a clear point of reference for the base and future baseline years.

Further investigation into existing datasets and research highlighted differences in scope, purpose or measurements, even within the same key indicator. Through the preliminary analysis, the most appropriate datasets to take forward to the methodology development were identified. Several methodologies were developed based on the appropriate datasets, with the advantages and limitations for each methodology discussed with the steering group members from MoT and Waka Kotahi. A key limitation in the methodologies was the lack of reliable data sources that was consistently projected at subnational level.

Considering data integrity, the resulting compounding error and model requirements in discussion with the steering group, the adopted methodology estimates light VKT and GHG emissions for 26 spatial areas, representing the Tier 1 and 2 urban environments and the rest of New Zealand. It utilises the

regional light VKT estimates from MoT and link level VKT estimates from the National Vehicle Emission Dataset (NVED)[1] to distribute light VKT to individual Territorial Local Authorities (TLAs) in the base year. For future years, it assumes the base year light VKT per capita remains unchanged and uses population projection to estimate light VKT within each TLA. The results are aggregated to spatial areas and adjusted to reconcile with the MoT observed and projected national totals. It uses base and projected light vehicle fleet GHG emissions factors from Vehicle Fleet Emission Model (VFEM) to calculate GHG emissions for the baseline spatial areas.

If more data becomes available, improvements can be made to the methodology to further refine the geographical differences across the urban environments.

Furthermore, the spatial areas defined for this research are focused on urban environments indicated in NPS-UD based on TLA boundaries. When applied on an individual project basis, these areas may not align with the project study area. Therefore, it is recommended for the agencies to do further investigation on providing guidance for practitioners; particularly on how to apply these subnational baselines to individual projects and how to consolidate the VKT savings or emission reduction from various projects to form a consistent total. It is also strongly recommended to continually improve on taking a system view to manage the programmes of work and the investment decision making framework, which includes any other enabling policies, processes, and tools.

[1] Derived from the Waka Kotahi Vehicle Emission Mapping Tool: https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/air-quality-climate/planning-and-assessment/vehicle-emissions-mapping-tool/

1 Introduction

1.1 Purpose

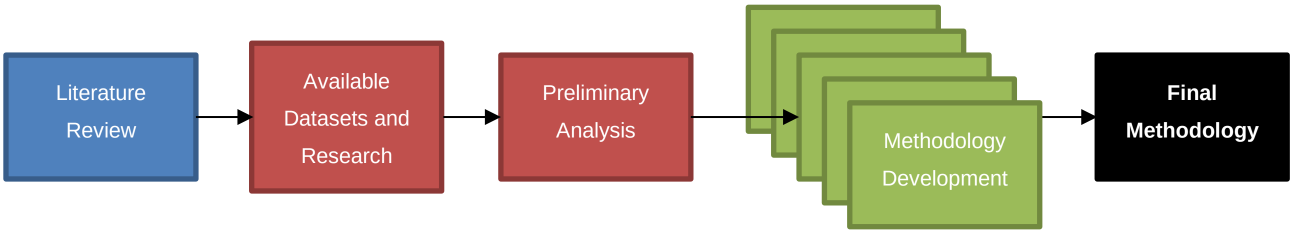
The New Zealand Government has set out strategic priorities for land transport through the Government Policy Statement on land transport[2]. A key strategic priority relates to environmental sustainability and the reduction of carbon emissions. The New Zealand government has committed to a 50% reduction of net emission below gross 2005 level by 2030 and net zero greenhouse gas (GHG) emissions by 2050[3]. A large proportion of New Zealand's current GHG emissions come from the transport sector, which is responsible for approximately 17% of gross domestic emissions and 39% of total domestic CO2 emissions[4]. Each region in New Zealand has different geographic, demographic and transport characteristics that influence vehicle kilometres travelled (VKT) and GHG emissions. To help achieve this, a transformation to low carbon transport systems is required.

To support the emission reduction vision for the transport system, Waka Kotahi is currently reviewing and investigating to establish subnational VKT and GHG emissions baselines for 2019, 2025, 2030 and 2035. Beca Ltd (Beca) was commissioned to undertake research on the available datasets that cover the historical observations and/or predicted trends for VKT and/or GHG emissions, and to develop a methodology to determine subnational VKT and GHG emissions baselines. For the purpose of this research, the baseline is defined as the business-as-usual scenario (see more details in Section 5.2.2).

1.2 Our approach

Our broad approach to developing a methodology for determining subnational VKT and GHG emissions baselines for 2019, 2025, 2030 and 2035 is shown in **Figure 1.1**.

Figure 1.1 Process for developing subnational VKT and GHG emissions baselines



Literature review

A literature review was carried out to understand emissions reduction targets and potential intervention types. This provided useful context for setting the subnational VKT and GHG emissions baselines.

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[2] Accessed through the Ministry of Transport website: https://www.transport.govt.nz/area-of-interest/strategy-and-direction/government-policy-statement-on-land-transport/

[3] Our Nationally Determined Contribution (NDC1) sets a headline target of a 50% reduction in net emissions below our gross 2005 level by 2030. Net zero emissions of all GHG other than biogenic methane by 2050 is a domestic target under the Climate Change Response Act.

[4] These figures are an estimate of 2019 transport emissions based on New Zealand's Greenhouse Gas Inventory 1990–2020

Available datasets and research

A review of current datasets and research was undertaken to understand the granularity, temporal continuity, and spatial coverage of the data sources and models. This review helped demonstrate what data sources and models could be worth exploring for use in setting subnational VKT and GHG emissions baselines.

Preliminary analysis

The available datasets were analysed to understand the differences in VKT estimates across sources and the relationship between VKT estimates and other variables. This analysis helped demonstrate the suitability of the different data sources and models for use in setting subnational VKT and GHG emissions baselines.

Methodology development

Multiple simple methodologies were developed to gain an understanding of different approaches to setting subnational VKT and GHG emissions baselines and the trade-offs between model accuracy and data integrity. This helped inform the range of characteristics to incorporate into the final methodology for setting the subnational VKT and GHG emissions baselines.

2 Literature review

The literature review focused on three documents. These documents set out the context for national emissions reduction targets, and the changes and initiatives required of the transport sector:

- The Ināia tonu nei Climate Change Commission (CCC) report[5]
- The Emissions Reduction Plan (ERP)[6]
- The National Policy Statement on Urban Development (NPS-UD)[7]

The key points of the CCC report include:

- Setting a clear path for each sector towards the goal of net zero emissions by 2050.
- Outlining how the transport sector can help achieve net zero emissions by 2050.

The key points of the ERP include:

- Outlining how the transport sector can reduce its GHG emissions.
- The emissions budgets for each sector.
- The requirement to reduce light VKT by 20% by 2035 through improved urban form and providing better travel options, particularly in our largest cities.

The key points of NPS-UD report include:

- Outlining the occurring shifts in urban environment development and why these are needed.
- How urban development will be shaped into the future.
- Establishing the definition of tier 1 and 2 urban environments, and their responsible local authorities.

The full review of these documents can be found in Appendix B.

[5] Accessed through the Climate Change Commission website: https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/

[6] Accessed through the Ministry for the Environment website: https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/

[7] Accessed through the Ministry for the Environment website: https://environment.govt.nz/acts-and-regulations/national-policy-statements/national-policy-statement-urban-development/

3 Available datasets and research

3.1 Key data and models

The key datasets and models considered for our research included:

- TMS (Traffic Monitoring System) and RAMM (Road Assessment and Maintenance Management) data
- Waka Kotahi VKT and emission data / models
- Ministry of Transport VKT and emission data / models
- Local government regional transport models
- Statistical New Zealand census data

These datasets vary in their temporal continuity (eg census years only compared to quarterly from 2002), granularity (eg link level compared to regional level) and spatial coverage (e.g. nation-wide compared to urban centres only). The following table briefly summarises these datasets. Appendix C has a full description of each dataset.

3.2 Other data and relevant research

The following datasets were also considered and explored, but did not significantly influence this research:

- Ministry of Transport 2020 Vehicle Fleet
- Waka Kotahi National Fleet
- Benchmarking Sustainable Urban Mobility

A full description of these datasets is provided in Appendix C.

Table 3.1 Key datasets and models by continuity, granularity and coverage

Source	Dataset	Description	Continuity	Granularity	Coverage
Waka Kotahi	TMS	Records of Annual Average Daily Traffic (AADT) for continuous traffic count sites across the State Highway network in New Zealand.	2012 – 2022	Links	Localised sites
	RAMM	Link level traffic counts observed (where there are count sites) and estimated for all roads across New Zealand. Annual VKT estimates at TLA (Territorial Local Authority) / regional level.	2002 – 2020	TLAs	Nation-wide
	Projected VKT	Quarterly VKT projection by vehicle type at national level. Estimated from econometric models by vehicle type, input data include GDP, employment, imports, exports and demographics information sources from Statistics New Zealand.	2002 to 2050	Nation	Nation-wide
	Emission Model	Vehicle Emission Prediction Model (VEPM), the model provides estimates that are suitable for air quality and GHG assessments and regional emission inventories.	2001 to 2050	N/A	N/A
	Emission Dataset	National Vehicle Emission Dataset (NVED), emission estimates for all public roads taking account of traffic count, fleet profile, speed and gradient.	2019 and 2020	Links	Nation-wide
Ministry of Transport	Quarterly Observed VKT	Quarterly VKT estimates by vehicle type at regional level. Estimated from WoF/CoF testing station observed odometer reading. This is also the latest VKT estimates produced by Ministry of Transport.	2002 Q1 to 2021 Q2	11 regions	Nation-wide
	Regional Observed VKT	Annual VKT and vehicle number estimates by vehicle type at regional level. Estimation based on odometer readings from the New Zealand Motor Vehicle Register and road use from the Waka Kotahi RAMM data.	2012/13 to 2018/19	14 regions	Nation-wide
	Projected VKT	Annual VKT and vehicle number estimates by vehicle type at regional level. Estimated from transport outlook household travel model, which provides projection of household travel in person kilometres by various modes.	5-year increments (2022/23 to 2057/58)	14 regions	Nation-wide
	Emission Model	Vehicle Fleet Emissions Model (VFEM), the model projects the makeup of future vehicle fleets and their kilometres travelled, energy use and greenhouse gas emissions.	2001 to 2055	Nation	Nation-wide
Local Government Transport Models	Auckland, Christchurch, Wellington	Three regional transport models were available for this research, Auckland, Wellington and Christchurch. The models provide projections of vehicle travel, including vehicle volume and speed predictions at a link level for both light and heavy vehicles.	AKL: 2018, 2038 CHC: 2018, 2038 WLG: 2013, 2036	Links	Urban centres
Statistics New Zealand	Census	Census estimated and projected household by type and population by age group at Statistical Area 2 (SA2) level.	5-year increments (2018 to 2058)	SA2s	Nation-wide

4 Preliminary analysis

This section documents the preliminary analysis carried out on the available datasets to determine their suitability for use in developing a methodology for setting subnational VKT and GHG emissions baselines. This included investigation on differences between various sources and the trend over time, at national and regional level.

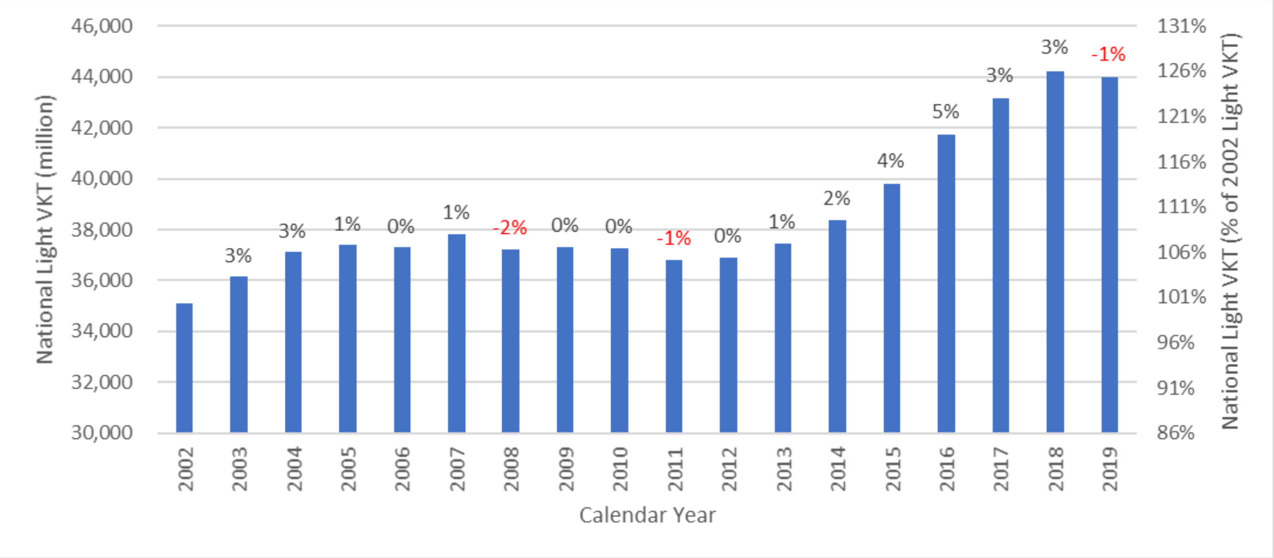
Light VKT made up for over 90% of the total VKT in the supplied datasets, and other vehicle classes typically respond to different variables (eg bus VKT varied more as a result of policy changes rather than variation in the underlying demand). Therefore, given the strategic priority in addressing the light VKT reduction required by the ERP, the analysis and methodology focuses on setting subnational VKT and GHG emissions baselines for light vehicles only.

4.1 National light VKT

The quarterly observed VKT and regional observed VKT from MoT give almost identical national totals. Both sources are based on odometer readings from the New Zealand Motor Vehicle Register, but the regional observed VKT also incorporates road use from the Waka Kotahi RAMM dataset.

As shown in Figure 4.1 for the MoT observed light VKT at a national level, the year-on-year growth rate ranges between -2% and 5% from 2002 to 2019. Negative and no growth periods were observed between 2008 and 2011, coinciding with the Global Financial Crisis in the late 2000s and more recently in 2019 prior to the global pandemic. Over the entire period, light VKT increased by approximately 25%, which is equivalent to a compound increase of 1.3% per annum.

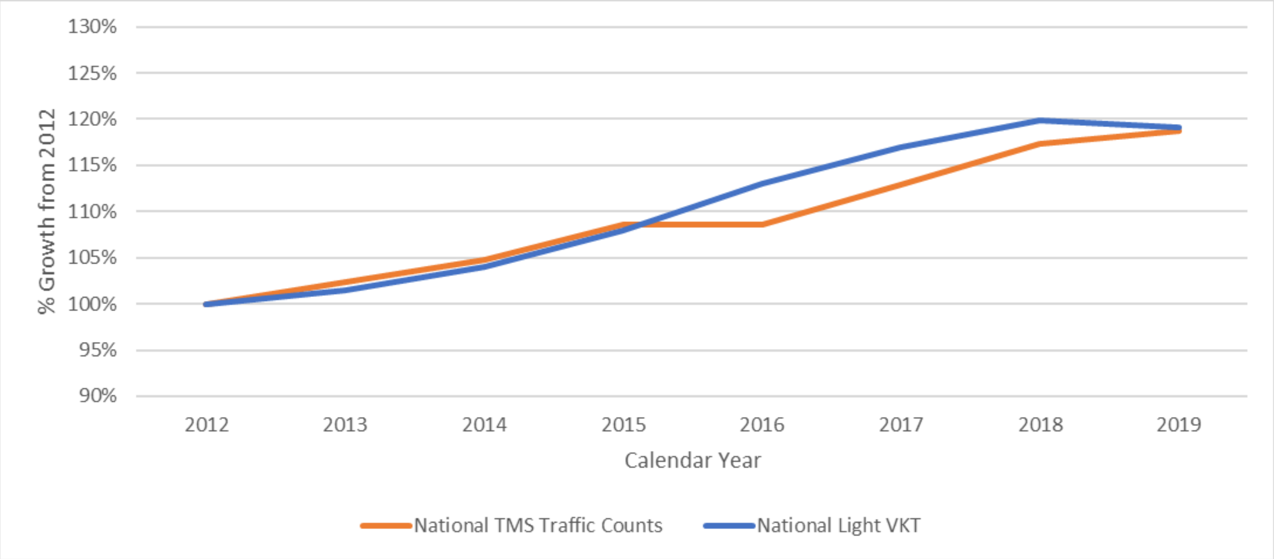
Figure 4.1 MoT observed light VKT (estimated from odometer readings) at national level



On the other hand, the NVED dataset provided by Waka Kotahi contains VKT data estimated from traffic counts based on RAMM for all public roads, independent of odometer readings. For 2019, the NVED estimated VKT about 2% higher than the observed at national level, which is a very small difference considering these two estimates were generated using significantly different approaches.

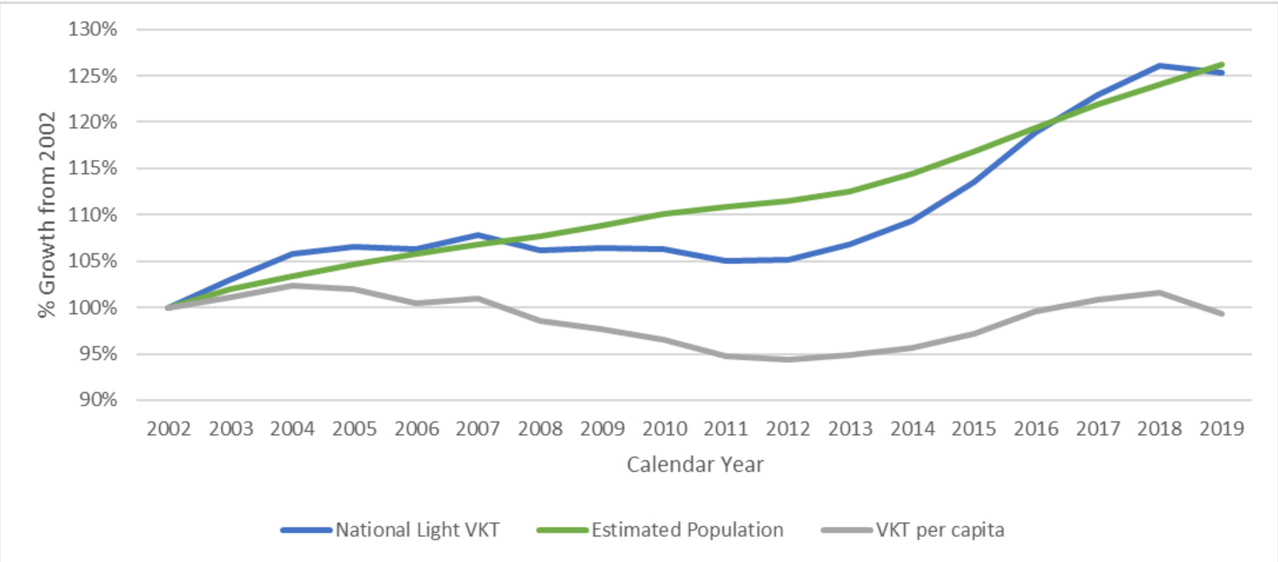
From 2012 to 2019, total TMS traffic counts on continuous sites followed a similar trend to the MoT observed light VKT at a national level, as shown in Figure 4.2. However, the TMS traffic counts are generally regarded as less reliable due to inconsistencies such as missing counts and days. In the data obtained from TMS website, all continuous sites had identical AADT estimates for 2015 and 2016. Therefore, this was deemed to be a less desirable approach for estimating and distributing light VKT to subnational areas.

Figure 4.2 Percentage difference in TMS traffic counts and MoT observed light VKT (estimated from odometer readings) at national level indexed to 2012



From 2002 to 2019, total population also followed a similar trend to the MoT observed light VKT at a national scale, as shown in Figure 4.3. This relationship suggests that national VKT per capita remained relatively constant over this period and could be an appropriate variable for estimating and disaggregating light VKT.

Figure 4.3 Percentage difference in MoT observed light VKT (estimated from odometer readings), estimated population, and resulting light VKT per capita at national level indexed to 2002



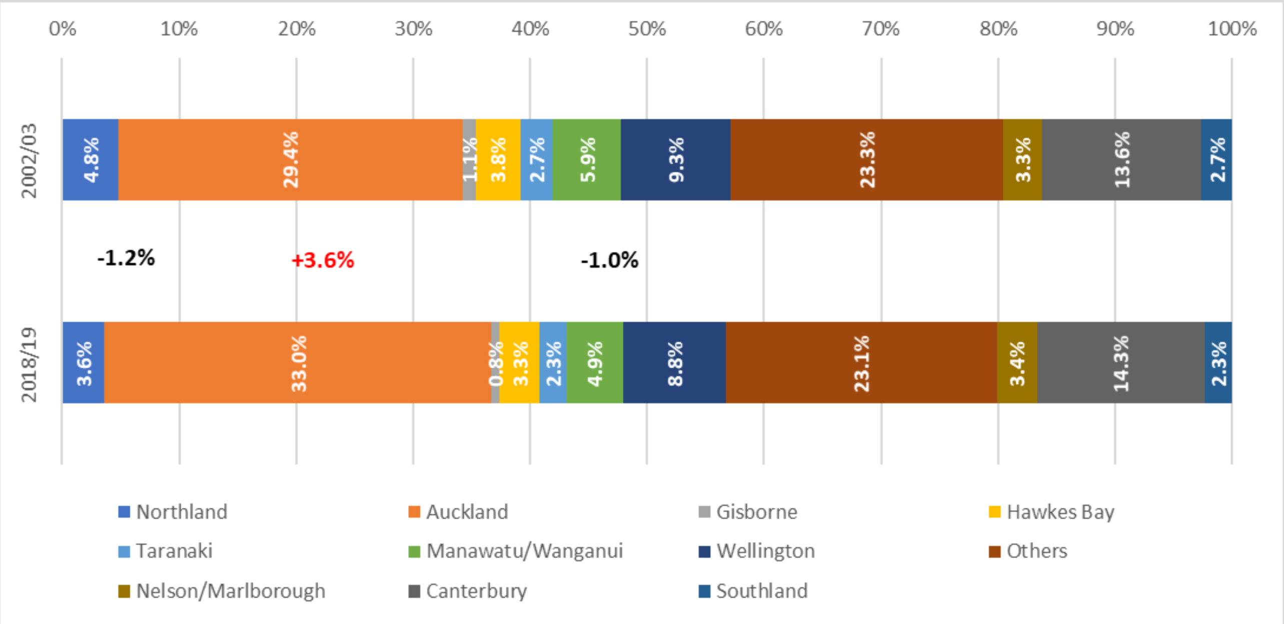
This relationship was also captured by the Waka Kotahi econometric VKT projection model, which used population as one of the predictors for total VKT. For the national light VKT projection, however, the Waka Kotahi model found fulltime employment (FTE) to have better fit when compared to total population. It is noted that the total population values used in the Waka Kotahi VKT model are slightly larger than the estimated resident population reported by Statistics New Zealand at census years (2006, 2013 and 2018).

4.2 Subnational light VKT

While at a national level, the difference in observed light VKT due to financial and calendar year was omittable; at subnational level, the absolute and proportional shares of VKT between the two observed VKT datasets from MoT have considerable differences. As stated in Table 3.1, the regional observed VKT is more granular and divides the country up into 14 regions; while the quarterly observed VKT combines part of the South and North Island into one region (referred to as ‘Other’, including Waikato, Bay of Plenty, West Coast and Otago). However, as the regional observed data is only available in financial years, for consistency, all comparison at subnational level was done in financial years.

The proportional share of light VKT across the regions specified in the MoT observed light VKT remained relatively constant over time. From financial year 2002/03 to 2018/19 in the MoT quarterly observed VKT, the Auckland region’s proportional share increased by 3.6%, while that of the Northland and Manawatu/Wanganui regions decreased by 1.2% and 1.0% respectively, as shown in Figure 4.4. All other reported regions’ proportional share changed by less than 1% during this time. Furthermore, the proportional share of light VKT is comparable to the proportional share of total population at census years as reported by Statistics New Zealand (2006, 2013 and 2018). This further suggests that population values could be appropriate for VKT estimation and disaggregation to a subnational level.

Figure 4.4 Proportional share of MoT quarterly observed light VKT across regions from 2002/03 to 2018/19



However, there is no obvious relationship when comparing the change in MoT quarterly observed light VKT and population within individual regions over time. For example, Figure 4.5 shows that in Northland there is an increase in population (+8%) but decrease in light VKT (-14%) from 2006 to 2013; meanwhile Figure 4.6 shows that between 2013 and 2018, there is an increase in population (+13%) and light VKT

(+10%). This suggests that population values alone may have limited explanatory power for regional changes in light VKT.

Figure 4.5 Regional census population and MoT quarterly observed light VKT percentage change from 2006 to 2013

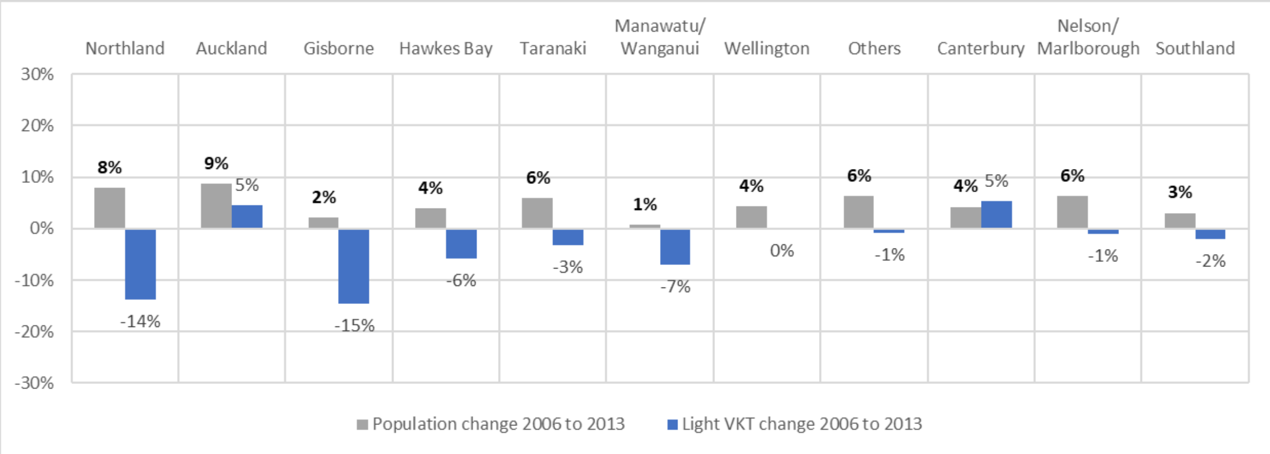
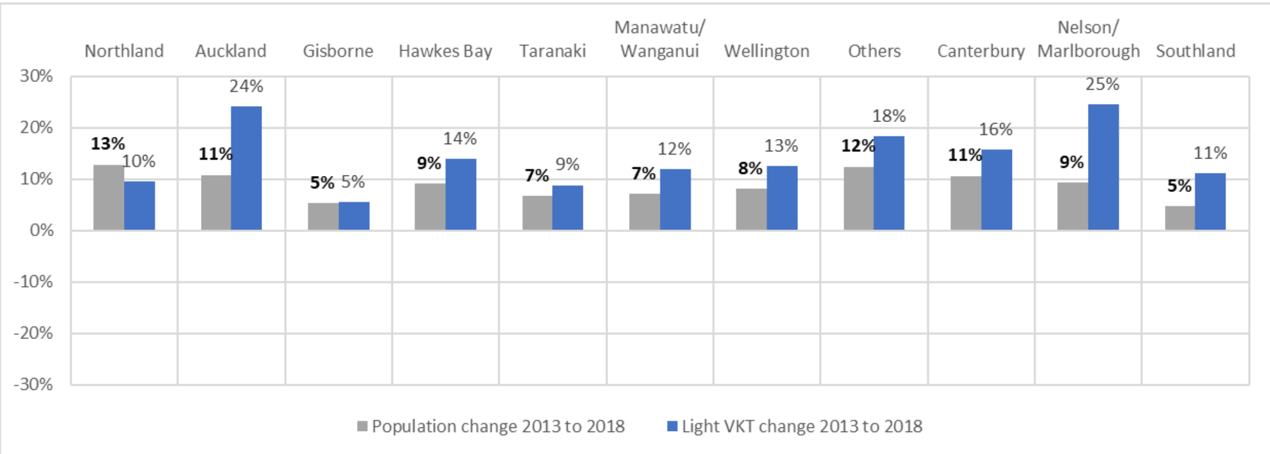


Figure 4.6 Regional census population and MoT quarterly observed light VKT percentage change from 2013 to 2018



There are differences in regional values and proportional shares between MoT quarterly observed total VKT (in quarters) and VKT from NVED (in calendar years) for 2020 (see Figure 4.7 and Figure 4.8). It appears that the Waka Kotahi NVED produces larger VKT estimates for regions that have smaller populations and less urban development compared to the MoT quarterly observed VKT. This could relate to the methodology differences in estimating VKT between these two sources (as highlighted in Appendix C).

Figure 4.7 Proportional share of MoT quarterly observed and Waka Kotahi NVED VKT across regions at 2020

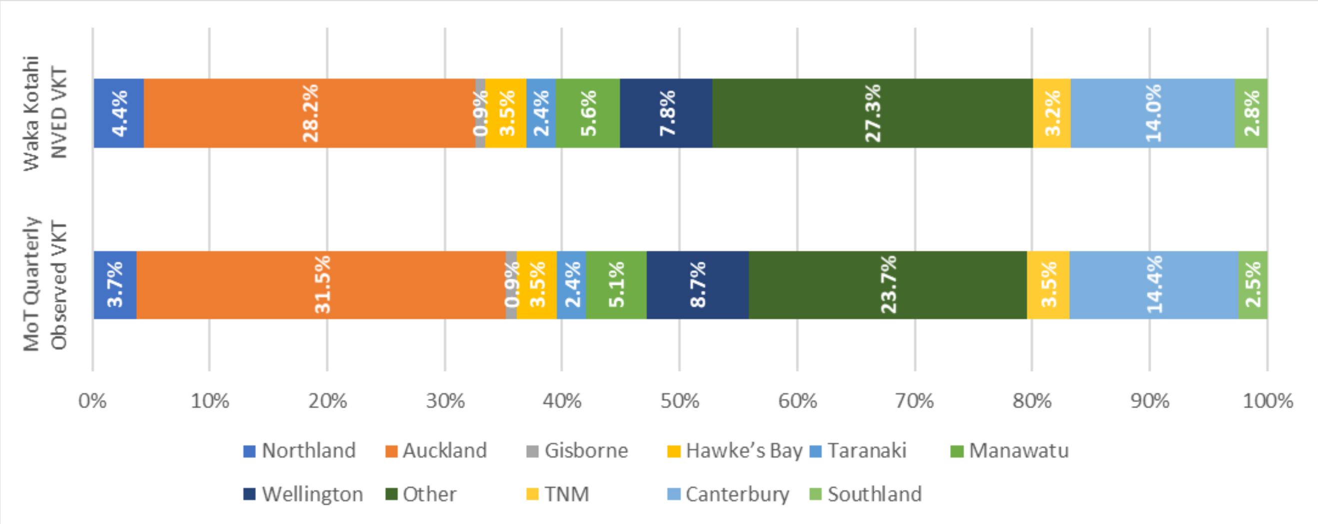
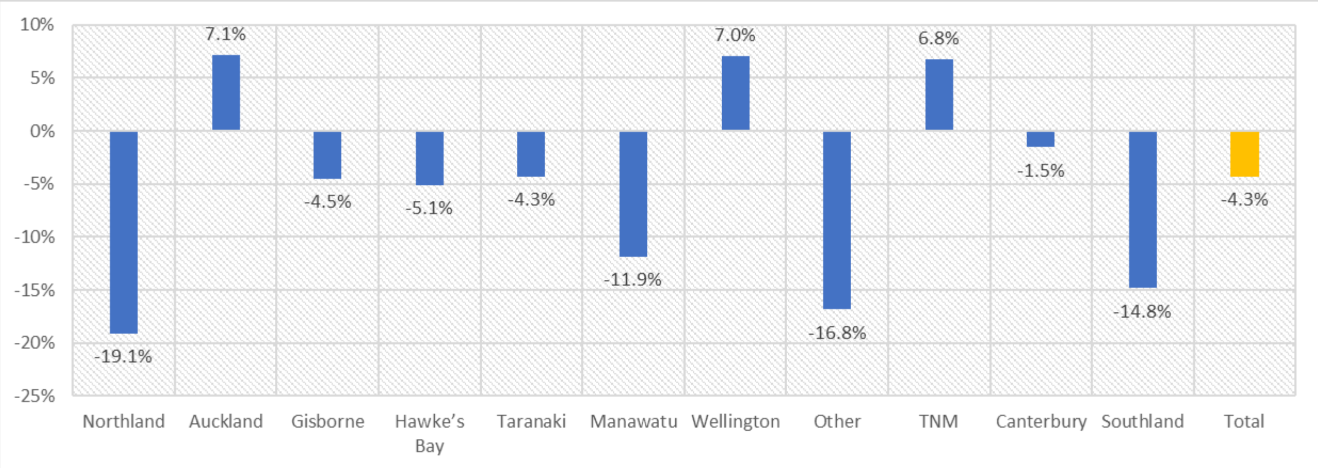


Figure 4.8 Difference in regional VKT between MoT quarterly observed and Waka Kotahi NVED – as percentage of Waka Kotahi NVED VKT at 2020



Note that in, Figure 4.7, and Figure 4.8 'TNM' region refers to Nelson, Marlborough, and Tasman regions; while 'Other' region refers to the sum of Bay of Plenty, Otago, Waikato and West Coast regions.

4.3 Transport models

Transport models have the potential to make this project's subnational VKT estimates more realistic and nuanced. However, there are some limitations to their comparability to other sources of VKT.

In its supplied state, the Wellington Transport Strategic Model (WTSM) study area aligns with the Greater Wellington regional boundary. Similarly, for Auckland Regional Model (MSM), the study area aligns with Auckland regional boundary. On the other hand, the Christchurch Transport Model (CTM) study area covers Christchurch City Council area, part of Selwyn and Waimakariri District. As the area does not align with the Canterbury regional boundary, it cannot be compared with observed and projected VKT from MoT. However, VKT from NVED has link level granularity, so the exact links covered by the Christchurch model can be extracted from NVED for comparison.

The WTSM model gives forecasts for 2013 and 2036; linear interpolation and extrapolation is used to produce VKT estimates to 2018 and 2038 that can be compared to observed and projected VKT. The Auckland and Wellington transport models under their respective assumed scenarios give smaller VKT estimates at both 2018 and 2038 than all other comparable VKT data sources (see Figure 4.9 and Figure 4.10). The largest differences are seen in these two models' 2038 estimates, which are 21.4% and 16.4% lower than the MoT Projected VKT estimates for these two regions at 2037/38.

For all three urban centres, there is an observed reduction in VKT per capita in the future when compared with the base year (from 2018 to 2038, -4.7% for Auckland, -0.6% for Wellington, and -1.8% for Christchurch). However, it is also worth noting that all of the forecast year scenarios from these transport models include future transport interventions that increases network capacity and promotes mode shift to non-car modes (eg the MSM standard future scenario includes ATAP schemes). Therefore, the reduction in VKT per capita may not be valid for baseline scenarios. Adjusting regional estimates for VKT based on implied interventions from transport models is possibly overly complex and out of scope for this research project.

Figure 4.9 Total VKT of Auckland from multiple sources over time

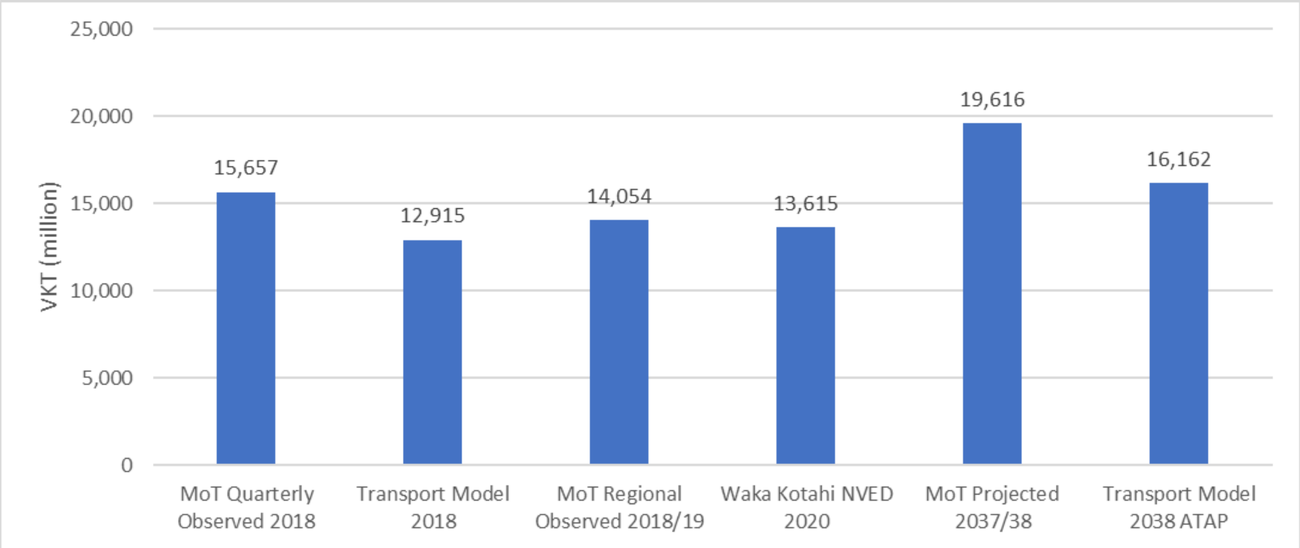
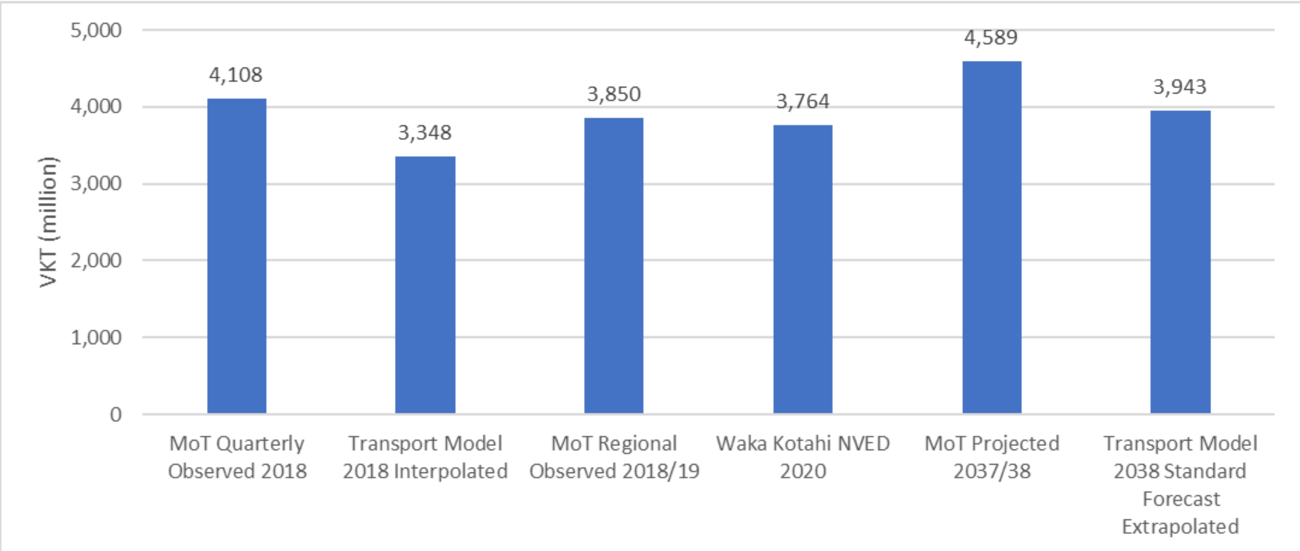


Figure 4.10 Total VKT of Wellington region from multiple sources over time



5 Methodology

5.1 Initial methodologies

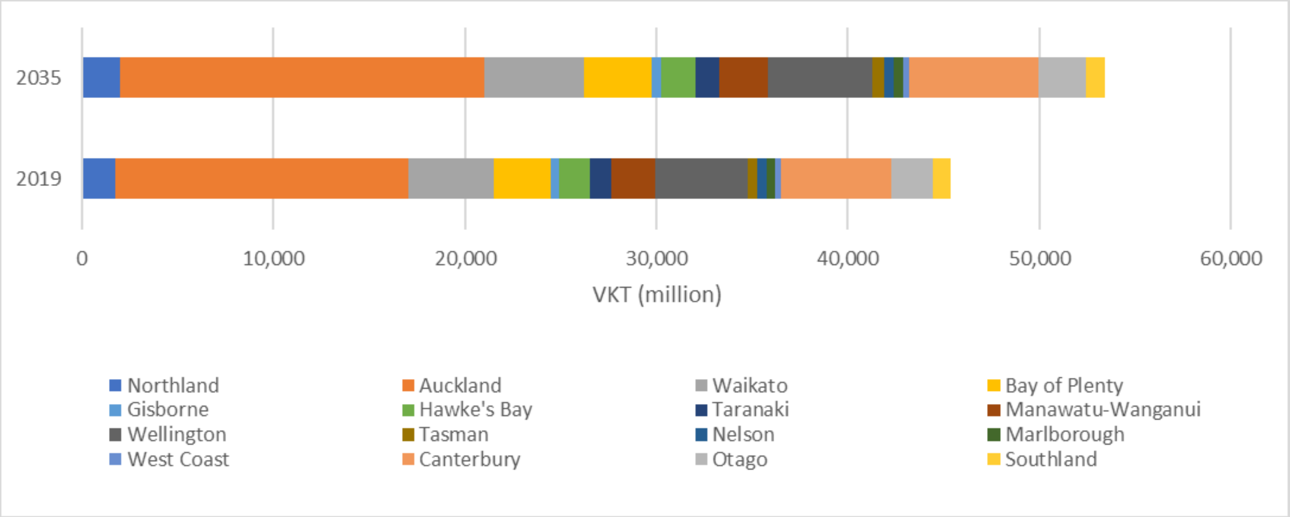
Based on preliminary analysis, several simple methodologies were explored for estimating subnational light VKT. This section documents these initial methodologies, which were calibrated at a regional level and controlled to Waka Kotahi national projection for exploration purposes. It is worth noting that findings from these initial methodologies were used as discussion points in the steering group workshop to refine and develop the adopted methodology for urban environments. Finally, the adopted methodology is adjusted to MoT national projection.

5.1.1 Proportional split

The proportional split method works on the observation that the regional VKT as a proportion of the national VKT remains relatively consistent over time (as demonstrated in Figure 4.4). At an individual region level, there is no obvious relationship between VKT growth and population growth over time (as demonstrated in Figure 4.5 and Figure 4.6). However, as a proportion of the national total, the regional population appears to be a reasonable indicator for light VKT.

On that basis, this method disaggregates the national light VKT estimate solely by regional population as the proportion to the total population. For a given year, the Waka Kotahi national projected light VKT estimate is split into regions using the respective region population proportion. Figure 5.1 shows the indicative output created from this method.

Figure 5.1 Indicative outputs from proportional split method – regional light VKT at 2019 and 2035

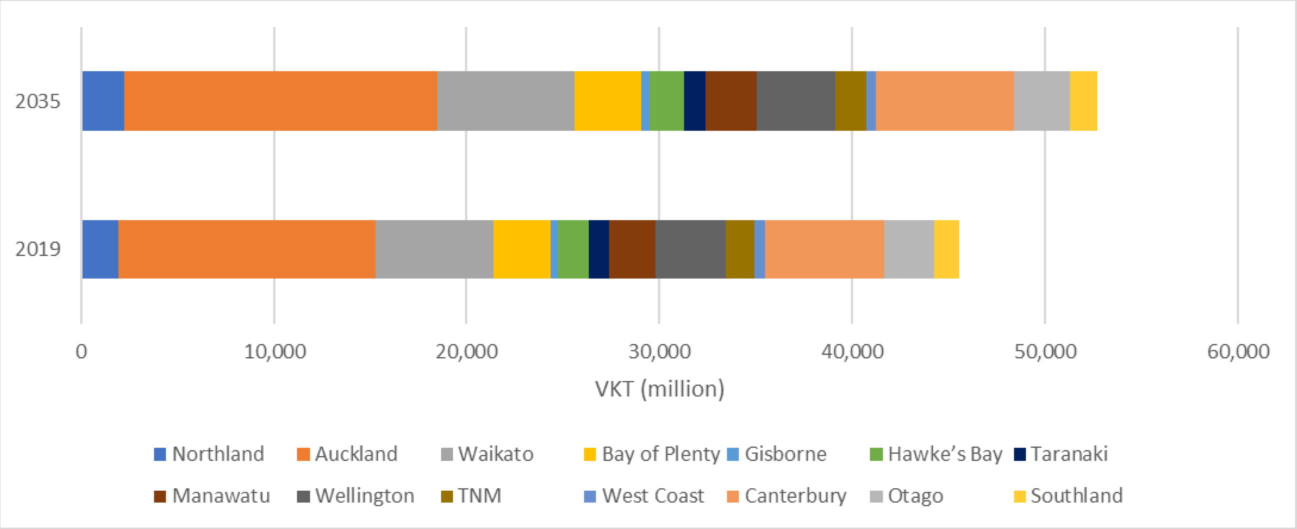


This method provides a top-down approach that ensures the regional estimates are controlled to the Waka Kotahi national projected light VKT without the need for adjustment factors. However, it implies a uniform VKT per capita across all regions for a given year, which is an oversimplification. For more densely populated urban environments, such as Auckland, the VKT per capita would likely to be lower than sparsely populated areas like West Coast.

5.1.2 Single indicator projection

Building on the proportional split method, the single indicator projection methodology uses light VKT per capita for each region at the base year and regional population values to calculate regional light VKT estimates. For the base year (in this case 2018), the light VKT per capita is calculated for each region using the MoT regional observed light VKT and regional population from the census. For the future years, the regional population projection is used to calculate regional light VKT estimates by applying the light VKT per capita from the base year. Figure 5.2 shows the indicative output created from this method.

Figure 5.2 Indicative outputs from single indicator projection method – regional light VKT at 2019 and 2035



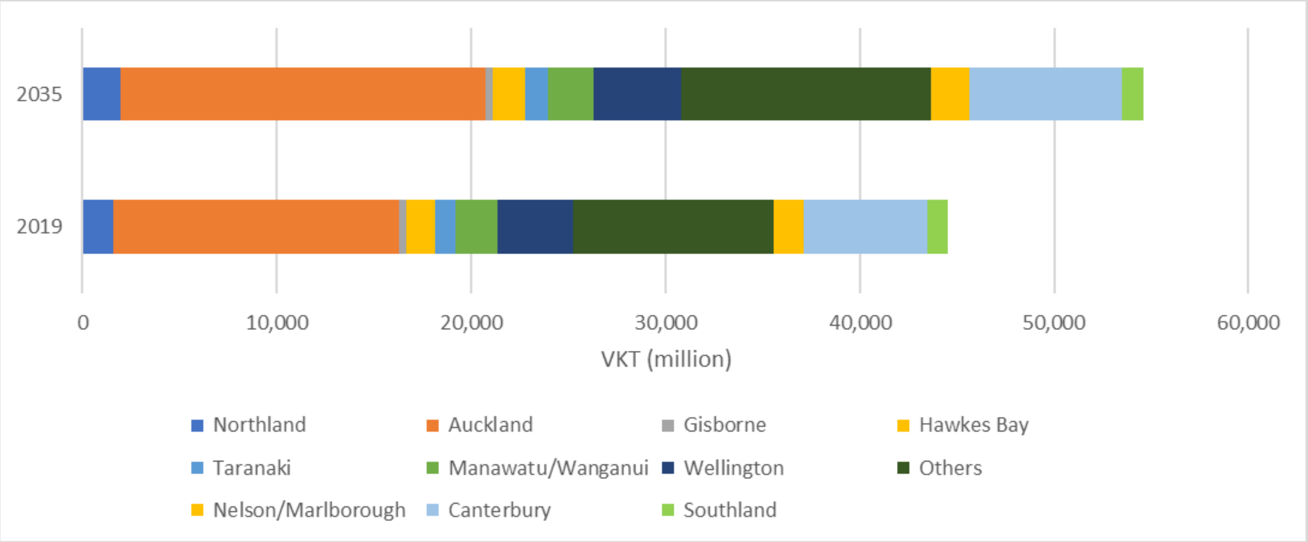
This method provides a bottom-up approach that estimates light VKT at a regional level. This means that additional adjustment factors are required to ensure the regional totals align with the Waka Kotahi national light VKT projection. However, indicative results suggests (based on 2018) that the gap between regional totals calculated from this method and the Waka Kotahi national projection is relatively small (Less than 2% for both 2019 and 2035).

5.1.3 Autoregressive model

Building on the single indicator projection method, the autoregressive model methodology drew inspiration from the Waka Kotahi VKT projection model, which is an autoregressive distributed lag (ARDL) model using econometric indicators such as petrol prices and GDP to estimate VKT.

Therefore, this method builds autoregressive models for each region using regional population and national petrol prices as the indicators. Each model is fitted to the historical MoT quarterly observed light VKT of the respective region. Figure 5.3 shows the indicative output created from this method.

Figure 5.3 Autoregressor of Waka Kotahi observed light VKT



Like the single indicator projection method, this method is a bottom-up approach that would require adjustment to match with the national projection. While it does consider factors such as petrol elasticities, due to availability of continuous regional VKT data, this model was built on the coarser regional definition provided by the MoT quarterly observed dataset. It combined areas from both the North and South Island into one region ('Others') and, as a result, the indicative results from this model had wider gaps to the national projections compared to the single indicator method.

5.1.4 Comparison of initial methodologies

Table 5.1 summarises how each of the initial methods compared against the assessment criteria.

Table 5.1 Qualitative rating of considered methodologies

Assessment criteria	Proportional split	Single indicator projection	Autoregressive model
Modelling Tiers	No Tier - 14 regions	No Tier - 14 regions	No Tier - 11 regions
Model Description	Simple proportion based on observed regional population estimates / projection	Projecting from VKT per capita of each region in 2018 with population values interpolated from census data	Calculating VKT from observed and projected regional population values and national petrol prices, and observed regional VKT
Integrity \ Accuracy	Low	Medium	Medium
Consistency	High	High	High
Practical implementation / Updateability	High	High	High
Moderated to actual regional/national totals	Yes	No	No
Availability	Nation-wide	Nation-wide	Nation-wide
Granularity	Low	Low	Low

Based on these findings and the subsequent discussion with the steering group, the adopted model would be population based and focus on urban environments.

5.2 Adopted methodology

At a national level, MoT and Waka Kotahi have built reliable VKT estimates observed from odometer readings and projected using econometric models. The focus on the subnational model is therefore to distribute the national level light VKT estimates to Tier 1 and 2 urban environments in line with the latest ERP.

Considering the feedback from the steering group, Figure 5.4 illustrates the adopted methodology for the baseline model. The following subsections describe the process of defining the spatial definition for the subnational VKT calculation and the corresponding distribution model.

Figure 5.4 Adopted methodology approach

5.2.1 Spatial definition

As stated in Section 0, the NPS-UD defines that:

- Tier 1 consists of five urban environments over 14 TLAs,
- Tier 2 consists of eight urban environments over 12 TLAs.

A number of existing definitions were explored when defining the spatial boundaries for these thirteen Tier 1 and 2 urban environments. These included:

- Regional transport model study areas (Auckland, Wellington and Christchurch)
- Statistics New Zealand 2018 regional boundaries (16 areas)
- Statistics New Zealand 2018 Functional urban areas (FUA) (53 areas)
- Statistics New Zealand 2018 TLA boundaries (66 areas)

Regional transport model study areas were generally created to encapsulate most of the travel pattern changes from transport interventions within its boundaries. However, not all of the 13 urban environments have standalone regional transport models and these areas do not cover the entire country, which makes it difficult to align the subnational totals to national values.

Many of the datasets were available at a regional level, however, the regional areas tend to be too large to capture changes for urban environments.

FUAs were created from commuter travel patterns in 2018 census based on workplace address and usual residence address at statistical area 1 (SA1) level. While they may adequately capture material differences in travel patterns of potential interventions in the base year, they do not consider the expansion of urban areas due to development in the future year. Moreover, at the most granular level, population projections were only available at statistical area 2 (SA2) level, which is more aggregate comparing to SA1 that FUA was built from. Lastly, like the regional transport model study areas, FUAs do not cover the entire country.

TLAs were deemed the most suitable in terms of its alignment with data sources and jurisdictional boundaries. However, the areas tend to be too small for Tier 1 urban environments (eg Wellington). The final spatial area definition, therefore, consists of 26 spatial areas made from aggregating the 66 TLAs (see full correspondence table in Appendix A)

Table 5.2 below summarises the design principles used to define the final spatial area spatial boundaries and how each of these definition tracks against them.

Table 5.1 Design principles to define the final spatial area spatial boundaries

Design principles	Transport models	Region	FUA	TLA	Spatial areas
Reflect material differences in travel patterns of likely type of intervention	Y		Y		Y
Account for future urban areas expected within 2035 horizon	Y			Y	Y
Align with definitions used in common, long running forecasts	Y	Y		Y	Y
Align with jurisdictional boundaries that may have different responses				Y	Y
Align with existing policy definitions	Y			Y	Y
Align with purpose of the work and ability to readily update the assessments		Y		Y	Y
Align with transport models to allow transfer for forecasting data in needed	Y	Y		Y	Y

5.2.2 Baseline definition

In the original scope for the project, the output of this research is to provide consistency across urban environments and a clear point of reference to be used for climate impact policy assessment primarily at a strategic systems level while being useful to business case development and evaluation, and environmental permitting.

Therefore, for the purpose of this research, we have defined baseline as the business-as-usual scenario. This assumes no new transport interventions would take place to promote mode shift.

5.2.3 Subnational VKT distribution model

At its core, the subnational distribution model utilises the latest regional light VKT estimates from MoT and NVED data to distribute light VKT to individual TLAs in the base year (2019). For future years (2025, 2030 and 2035), it uses the base year light VKT per capita and population projection interpolated from census years (2018, 2023, 2028, 2033 and 2038) to estimate light VKT within each TLA.

It is worth noting that regional boundaries do not have a one-to-many relationship with TLA boundaries, as demonstrated by Figure 5.5 where Rotorua is spread across Bay of Plenty and Waikato region.

Figure 5.5 Rotorua spread across Bay of Plenty and Waikato regions

Altogether, the 16 regions and 66 TLAs divide the entire country into 74 distinct areas with no overlap. Moreover, given that the most granular light VKT data from MoT was at regional level, link level light VKT data from 2019 NVED was aggregated by the 74 distinct areas to calculate the factors for distributing regional level VKT to relevant TLAs.

It is worth noting that the latest observed VKT from MoT (quarterly observed) combines regions from both the North and South Island into the 'Other' region. To obtain more refined regional data, regional observed VKT from MoT was used to disaggregate the 'Other' region into Waikato, Bay of Plenty, West Coast and Otago. The resulting regional data is then disaggregated by the NVED data to create the TLA results.

The TLA results are then aggregated to 26 spatial areas and adjusted to reconcile with the MoT national totals. Light vehicle fleet GHG emission factors at a national level from the Vehicle Fleet Emissions Model

(VFEM) were used to calculate GHG emissions for the spatial areas. Table 5.3 below summarises the national adjustment factors and GHG emission factors from VFEM.

Table 5.2 National adjustment factors and light vehicle GHG emission factors from VFEM

Factor Type	2019	2025	2030	2035
National Adjustment Factor		3%	5%	7%
Grams of CO2-e per VKT	215.9	199.3	180.6	154.2

5.2.4 Other indicators considered

Previous versions of the model included a range of other indicators, but these were disregarded due to limitations in projected data and lack of consistent response through time. The decisions for excluding these indicators have all been discussed and agreed with by the steering group. These are described in subsections below.

5.2.4.1 Fulltime employment (FTE)

FTE was shown to be the better indicator for light VKT estimation from the econometric VKT projection model from Waka Kotahi at national level when compared with total population. Indicative models built by Waka Kotahi suggested that the coefficient of determination between light VKT and total population was only 0.73, comparing to 0.86 between light VKT and FTE. However, TLA level projection of FTE is not consistently available for future years. Therefore, it is not included in the baseline distribution model.

5.2.4.2 Working age population

With the absence of FTE projections, working age population was trialled as a proxy for FTE. According to analysis done by Environment Health Intelligence NZ (EHINZ), the working age for New Zealand is between 15 and 64 years. However, subnational distribution models built with working age population at TLA level aggregated to the national total had a wider gap with MoT national total light VKT estimates. Moreover, while working age population may be a good proxy for FTE, with the absence of other indicators such as GDP at an urban area level, it did not appear to have better explanatory power at urban area level comparing to total population. Therefore, total population is used instead for the baseline distribution model.

5.2.4.3 Petrol elasticity

Petrol elasticity was built into the beta distribution model for regions with population under the assumption that the petrol elasticity would vary across the regions. However, the resulting models built from historical data between 2002 and 2020 showed no significant relationship for any of the regions between changes in petrol prices and changes in total VKT. Moreover, it is difficult to find reliable petrol price projections. Therefore, it is excluded from the baseline distribution model.

5.2.4.4 Historical RAMM data

As mentioned in Appendix C, the majority of the TLA level VKT data from RAMM is not broken down by vehicle class (only 39% of the VKT is classified as light). Moreover, at a national level, RAMM estimated VKT appears to lag behind the MoT observed VKT data by a year, which is likely due to the difference in how data was collated into RAMM from different councils. At a regional level, RAMM suggested a reduction in the share of Auckland total VKT (from 30% in 2006 to 28% in 2020), whereas MoT regional VKT suggested otherwise (from 30% in 2006 to 31% in 2020). Due to these differences at a national and regional level, RAMM data was not used for building the distribution model.

5.2.4.5 Transport model outputs

While transport models provided detailed link level forecasts for most of the Tier 1 urban environments, these models are largely inconsistent with each other. In particular, the models are calibrated to different base years (as demonstrated in Appendix C) and the assumptions used for the future year scenarios usually included network improvements that are not inside the currently committed programme of works. Therefore, outputs from the transport models were excluded from the final distribution model.

5.3 Limitations and future improvement opportunities

As demonstrated in Table 3.1, the datasets and models available at the time of this research vary in their assumptions, granularity, and coverage. To have a baseline consistent across the urban areas, some datasets such as transport model outputs had to be excluded from the methodology. Moreover, datasets, such as fulltime employment and GDP that can be used as indicators for predicting light VKT do not have reliable projections for future years at subnational level.

Taking account of these inconsistencies and trade-offs, the adopted methodology for subnational VKT and GHG emissions baselines has adopted a simple population-based approach. Adjustments are made to align the subnational baseline projection totals to national VKT estimates, so that additional VKT growth not captured by this simple approach can be accounted for.

Albeit simple, the adopted method is forecastable and adaptable for potential future iterations of this work. Improvements that can be made to address the limitations in the current method if more subnational level data becomes available are listed below:

- To account for the VKT growth not captured by the adopted approach, adjustment factors are applied to the subnational projections so that the projection total matches with the MoT national VKT projection. It is a uniform factor applied to all areas, as there is not enough subnational level data to support otherwise. This factor can be set to vary by the urban area, which would improve the reliability of the projections. It can also be updated as new regional or national level projection from MoT becomes available.
- If business-as-usual scenarios can be created consistently across transport models for urban environments, results from these models can be applied to further vary the baseline VKT per capita by urban environments.
- AADT estimates from continuous sites in TMS data appeared to correlate well with VKT growth during preliminary analysis, but they were excluded due to data quality issues (as discussed in Section 4.1). If the data can be cleaned and realigned with the other sources, it can be used as additional indicators to refine the baseline model.

6 Results

Table 6.1: summarises the subnational light VKT and GHG emissions baselines calculated from the adopted methodology for Tier 1, 2 and 3 urban areas for baseline year 2019 and 2035.

Table 6.1 Subnational light VKT and GHG emissions baselines – 2019 and 2035

Tier	Urban Area	Light VKT (million)		Light Vehicle GHG Emissions (kilo tons CO_2-e)	
		2019 Baseline	2035 Baseline	2019 Baseline	2035 Baseline
1	Auckland	14,425	18,749	3,114	2,890
1	Christchurch	4,382	5,560	946	857
1	Hamilton	2,712	3,580	586	552
1	Tauranga	1,525	1,971	329	304
1	Wellington	3,426	4,061	740	626
2	Dunedin	751	852	162	131
2	Napier-Hastings	1,153	1,381	249	213
2	Nelson Tasman	1,013	1,207	219	186
2	New Plymouth	626	746	135	115
2	Palmerston North	455	535	98	82
2	Queenstown	559	807	121	124
2	Rotorua	559	653	121	101
2	Whangarei	773	949	167	146
Rest of New Zealand	Gisborne	355	411	77	63
	Marlborough	512	587	111	90
	Rest of Bay of Plenty	465	525	100	81
	Rest of Canterbury	2,161	2,515	467	388
	Rest of Hawkes Bay	308	358	66	55
	Rest of Manawatu-Wanganui	1,690	1,938	365	299
	Rest of Northland	820	1,008	177	155
	Rest of Otago	635	785	137	121
	Rest of Taranaki	568	626	123	97
	Rest of Waikato	2,159	2,506	466	386
	Rest of Wellington	437	514	94	79
	Southland	1,030	1,170	222	180
	West Coast	464	493	100	76
National Total		43,964	54,487	9,492	8,400

The main baseline for 2035 is based on the medium population projection and base GHG emission factors from VFEM. Additional scenarios are also created for interim emission budget periods (2025 and 2030) with different population projections (low, medium and high) in Table 6.2. They provide the lower and upper bounds for the future year estimates (2025, 2030 and 2035) using the following logic:

- Low: with low population projection, no national adjustment factor
- Medium: with medium population projection, with national adjustment factor
- High: with high population projection, with national adjustment factor

Table 6.2 Subnational light VKT and GHG emissions baselines – 2025, 2030 and 2035 (low medium and high estimates)

Tier	Urban Area	Light VKT (million)									Light Vehicle GHG (kilo tons CO_2-e)								
		2025 Baseline			2030 Baseline			2035 Baseline			2025 Baseline			2030 Baseline			2035 Baseline		
		Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
1	Auckland	15,035	16,112	16,773	15,517	17,471	18,681	15,941	18,749	20,560	2,997	3,212	3,344	2,802	3,155	3,373	2,457	2,890	3,170
1	Christchurch	4,556	4,881	5,080	4,656	5,237	5,594	4,735	5,560	6,088	908	973	1,013	841	946	1,010	730	857	939
1	Hamilton	2,875	3,066	3,177	2,986	3,331	3,534	3,085	3,580	3,881	573	611	633	539	602	638	476	552	598
1	Tauranga	1,611	1,727	1,802	1,653	1,857	1,987	1,684	1,971	2,161	321	344	359	298	335	359	260	304	333
1	Wellington	3,491	3,718	3,849	3,501	3,904	4,135	3,494	4,061	4,402	696	741	767	632	705	747	539	626	679
2	Dunedin	752	799	825	746	829	876	737	852	921	150	159	164	135	150	158	114	131	142
2	Napier-Hastings	1,180	1,256	1,300	1,189	1,324	1,403	1,192	1,381	1,497	235	250	259	215	239	253	184	213	231
2	Nelson Tasman	1,039	1,107	1,147	1,045	1,164	1,235	1,043	1,207	1,311	207	221	229	189	210	223	161	186	202
2	New Plymouth	639	680	703	644	716	758	646	746	808	127	135	140	116	129	137	100	115	125
2	Palmerston North	461	490	508	462	515	546	460	535	581	92	98	101	83	93	99	71	82	90
2	Queenstown	622	677	714	647	745	810	669	807	903	124	135	142	117	134	146	103	124	139
2	Rotorua	570	606	627	569	632	671	564	653	711	114	121	125	103	114	121	87	101	110
2	Whangarei	800	852	883	813	905	959	821	949	1,030	160	170	176	147	163	173	126	146	159
Rest of New Zealand	Gisborne	358	382	397	356	399	424	351	411	450	71	76	79	64	72	77	54	63	69
	Marlborough	517	551	571	513	572	609	505	587	641	103	110	114	93	103	110	78	90	99
	Rest of Bay of Plenty	469	500	518	461	516	548	449	525	573	93	100	103	83	93	99	69	81	88
	Rest of Canterbury	2,181	2,324	2,411	2,179	2,431	2,589	2,162	2,515	2,749	435	463	481	393	439	468	333	388	424
	Rest of Hawkes Bay	312	332	345	311	347	370	308	358	392	62	66	69	56	63	67	47	55	60
	Rest of Manawatu-Wanganui	1,704	1,813	1,879	1,693	1,886	2,004	1,669	1,938	2,112	340	362	375	306	341	362	257	299	326
	Rest of Northland	851	908	941	864	963	1,022	869	1,008	1,096	170	181	188	156	174	185	134	155	169
	Rest of Otago	659	703	730	669	748	795	674	785	855	131	140	145	121	135	144	104	121	132
	Rest of Taranaki	562	598	619	551	615	654	537	626	684	112	119	123	100	111	118	83	97	105
	Rest of Waikato	2,194	2,335	2,420	2,184	2,435	2,587	2,155	2,506	2,732	437	465	482	394	440	467	332	386	421
	Rest of Wellington	447	475	492	448	498	527	444	514	557	89	95	98	81	90	95	68	79	86
	Southland	1,029	1,096	1,136	1,020	1,139	1,210	1,004	1,170	1,275	205	219	226	184	206	218	155	180	196
	West Coast	449	478	497	437	489	523	421	493	543	89	95	99	79	88	94	65	76	84
National Total		45,364	48,468	50,343	46,116	51,667	55,050	46,623	54,487	59,512	9,043	9,662	10,036	8,326	9,329	9,940	7,187	8,400	9,174

7 Conclusion

This research sets up a consistent methodology for distributing the national level light VKT and GHG emissions estimates to Tier 1 and 2 urban environments. This methodology is used to create subnational VKT and GHG emissions baselines for 2019 and future emission budget periods (2025, 2030 and 2035). To develop the methodology, the research has investigated a range of datasets and models that either directly provide observations and those that can be used to project VKT and GHG emissions, and those that can be used as indictors to estimate VKT and GHG emissions.

The adopted methodology estimates light VKT and GHG emissions for 26 baseline spatial areas, representing the Tier 1 and 2 urban environments and the rest of New Zealand. It utilises the regional light VKT estimates from MoT and link level VKT estimates from the Waka Kotahi NVED to distribute light VKT to individual TLAs in the base year. For future years, it assumes the base year light VKT per capita remains unchanged and uses population projection to estimate light VKT within each TLA. For these major urban areas the use of population projections to explain growth in light vehicle use are shown to be robust. The results are aggregated to spatial areas and adjusted to reconcile with the MoT observed and projected national totals. It uses base and projected light vehicle fleet GHG emission factors from VFEM to calculate GHG emissions for the spatial areas.

A few variations of the model were explored. However, due to the limitation in projection quality and consistency, they were excluded from the adopted methodology. If more data becomes available, improvements can be made to the methodology to further refine the geographical differences across the urban environments.

Furthermore, the spatial areas defined for this research are focused on urban environments indicated in NPS-UD based on TLA boundaries. The application beyond policy and into practice of these Tier 1 and Tier 2 baselines needs further development.

Appendix A: Urban area definition

Table A.1 Tier 1 and 2 urban environments to TLA correspondence

Tier	Name	TLA	Region
1	Auckland	Auckland	Auckland
1	Christchurch	Christchurch City	Canterbury
1	Christchurch	Selwyn District	Canterbury
1	Christchurch	Waimakariri District	Canterbury
1	Wellington	Wellington City	Wellington
1	Wellington	Porirua City	Wellington
1	Wellington	Upper Hutt City	Wellington
1	Wellington	Lower Hutt City	Wellington
1	Wellington	Kapiti Coast District	Wellington
1	Tauranga	Tauranga City	Bay of Plenty
1	Tauranga	Western Bay of Plenty District	Bay of Plenty
1	Hamilton	Hamilton City	Waikato
1	Hamilton	Waikato District	Waikato
1	Hamilton	Waipa District	Waikato
2	Whangarei	Whangarei District	Northland
2	Rotorua	Rotorua District	Bay of Plenty
2	New Plymouth	New Plymouth District	Taranaki
2	Napier-Hastings	Napier City	Hawkes Bay
2	Napier-Hastings	Hastings District	Hawkes Bay
2	Palmerston North	Palmerston North City	Manawatu-Wanganui
2	Nelson Tasman	Nelson City	Nelson
2	Nelson Tasman	Tasman District	Tasman
2	Queenstown	Queenstown-Lakes District	Otago
2	Dunedin	Dunedin City	Otago

Table A.2 Rest of New Zealand areas to TLA correspondence

Name	TLA	Region
Rest of Bay of Plenty	Kawerau District	Bay of Plenty
Rest of Bay of Plenty	Opotiki District	Bay of Plenty
Rest of Bay of Plenty	Whakatane District	Bay of Plenty
Rest of Canterbury	Ashburton District	Canterbury
Rest of Canterbury	Hurunui District	Canterbury
Rest of Canterbury	Kaikoura District	Canterbury
Rest of Canterbury	Mackenzie District	Canterbury
Rest of Canterbury	Timaru District	Canterbury
Rest of Canterbury	Waimate District	Canterbury

Name	TLA	Region
Rest of Canterbury	Waitaki District	Canterbury
Rest of Hawkes Bay	Central Hawkes Bay District	Hawkes Bay
Rest of Hawkes Bay	Wairoa District	Hawkes Bay
Rest of Manawatu-Wanganui	Horowhenua District	Manawatu-Wanganui
Rest of Manawatu-Wanganui	Manawatu District	Manawatu-Wanganui
Rest of Manawatu-Wanganui	Ruapehu District	Manawatu-Wanganui
Rest of Manawatu-Wanganui	Tararua District	Manawatu-Wanganui
Rest of Manawatu-Wanganui	Whanganui District	Manawatu-Wanganui
Rest of Manawatu-Wanganui	Rangitikei District	Manawatu-Wanganui
Rest of Northland	Far North District	Northland
Rest of Northland	Kaipara District	Northland
Rest of Otago	Central Otago District	Otago
Rest of Otago	Clutha District	Otago
Rest of Taranaki	South Taranaki District	Taranaki
Rest of Taranaki	Waitomo District	Taranaki
Rest of Taranaki	Stratford District	Taranaki
Rest of Waikato	Hauraki District	Waikato
Rest of Waikato	Matamata-Piako District	Waikato
Rest of Waikato	Otorohanga District	Waikato
Rest of Waikato	South Waikato District	Waikato
Rest of Waikato	Thames-Coromandel District	Waikato
Rest of Waikato	Taupo District	Waikato
Rest of Wellington	Carterton District	Wellington
Rest of Wellington	Masterton District	Wellington
Rest of Wellington	South Wairarapa District	Wellington
Gisborne	Gisborne District	Gisborne
Marlborough	Marlborough District	Marlborough
Southland	Gore District	Southland
Southland	Invercargill City	Southland
Southland	Southland District	Southland
West Coast	Buller District	West Coast
West Coast	Grey District	West Coast
West Coast	Westland District	West Coast

Appendix B: Literature review – report details

Ināia tonu nei Climate Change Commission report

Ināia tonu nei: a low emissions future for Aotearoa Climate Change Commission (CCC) report is the CCC's first advice to the New Zealand Government on climate action in Aotearoa.

New Zealand has acknowledged the need to combat climate change and has committed to reaching net zero emissions of long-lived GHGs by 2050. A series of different emissions reduction targets have been adopted by successive governments.. The targets have changed over time, however the necessary action required to achieve emissions reductions at source have not been adequate with the focus on short term initiatives.

The approach to meeting the 2050 targets would require New Zealand to decarbonise the transport system completely. It outlines the necessary actions over the next 15 years to put New Zealand on track for the 2050 targets while delivering immediate emissions reductions. This means travelling less, or shorter distances; using public transport, walking and cycling more; and changing how most vehicles are powered to low emission vehicles.

Low-emission technologies, practices and processes can only be effective at reducing emissions if they are taken up by individuals and businesses. Transitioning to a low emissions economy will require New Zealanders to change some aspects of their lives. Many people will need to change the type of car they choose to drive and the ways they choose to travel. Creating an environment that enables New Zealanders to make choices that support low-emission outcomes is therefore critically important.

Transport makes up almost 33% of total long-lived GHG emissions in New Zealand. Action to reduce these is critical if New Zealand is going to reach its emissions reduction targets.

There is an opportunity to decarbonise transport by 2050. This can be achieved through a combination of the following means:

- Investing in the right infrastructure and systems.
- Encouraging changes to behaviour.
- Adopting technologies that are available now and improving fast.
- Reducing the reliance on cars (or light vehicles).
- Supporting people to walk, cycle and use public transport.

There needs to be clear targets and plans to meet those targets for increasing use of alternative modes other than private vehicles.

Emissions Reduction Plan

The purpose of the Emissions Reduction Plan (ERP) is to contribute to global efforts to limit temperature rise to 1.5°C above pre-industrial levels.

New Zealand was one of the first countries in the world to refer to the goal of limiting global warming to 1.5°C in primary legislation. The temperature goal drives the long-term targets, which are in turn broken down into a series of successive emissions budgets along the way.

Sub-targets will help track progress across key sectors over each emissions budget period, to make sure targets are on track across the economy. The emissions budgets for transport are 65.9 Mt CO_2-e[3] for 2022-25, 76.0 Mt CO_2-e[3] for 2026-30 and 56.8 Mt CO_2-e[3] for 2031-35.

The Avoid, Shift, Improve Framework can be implemented to the transport system as a way to help decarbonise the transport system and will deliver better transport for everyone in New Zealand. It also contributes to New Zealand being a more vibrant, resilient, and prosperous places to live, work and visit. It will reduce our reliance on volatile global energy markets. Avoid relates to not making trips that are not necessary, shift relates to changing the mode of transport used to make trips and improve relates to the energy efficiency of transport modes. More people need be able to walk, cycle and use public and shared transport options, particularly in our largest urban areas. This will reduce congestion, air pollution and noise, create better places to live in, and support public health and wellbeing.

Three focus areas that will guide the reduction in transport emissions include:

- Reduce reliance on cars and support people to walk, cycle and use public transport
- Rapidly adopt low-emissions vehicles
- Begin work to decarbonise heavy transport and freight

The government has set four targets for the transport sector, of which one is to reduce total kilometres travelled by the light vehicle fleet by 20% by 2035 through improved urban form and providing alternative transport options, particularly in the largest cities.

The amount that people travel in fossil-fuelled vehicles is at the heart of the transport emissions challenge. There cannot be a reliance on just decarbonising the vehicle fleet quickly. Improving urban form, offering alternative transport options, and using other demand management levers to reduce VKT by cars is vital. Most of this reduction needs to occur in the largest cities, where people are more likely to have transport options other than travelling by private car. These measures can also deliver significant benefits beyond reducing emissions, such as improving travel choice and accessibility, better health and safety, and less congestion. The actions called for in the ERP Transport Chapter include:

- Integrate land-use planning, urban development and transport planning and investments to reduce transport emissions
- Support people to walk, cycle and use public transport
- Enable congestion charging and investigate other pricing and demand management tools to reduce transport emissions
- Require roadway expansion and investment in new highways to be consistent with transport targets
- Embed nature-based solutions as part of the response to reducing transport emissions and improving climate adaptation and biodiversity outcomes.

National Policy Statement on Urban Development

The National Policy Statement for Urban Development (NPS-UD) sets out eight objectives which have guided the policy direction behind the NPS-UD, these eight objectives are:

- New Zealand has well-functioning urban environments that enable all people and communities to provide for their social, economic, and cultural wellbeing, and for their health and safety, now and into the future.
- Planning decisions improve housing affordability by supporting competitive land and development markets.

- Regional policy statements and district plans enable more people to live in, and more businesses and community services to be in, areas of an urban environment in which one or more of the following apply:
    - The area is in or near a centre zone or other area with many employment opportunities
    - The area is well-serviced by existing or planned public transport
    - There is a high demand for housing or for business land in the area, relative to other areas within the urban environment.
- New Zealand's urban environments, including their amenity values, develop and change over time in response to the diverse and changing needs of people, communities, and future generations.
- Planning decisions relating to urban environments, and FDSs, consider the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).
    - Local authority decisions on urban development that affect urban environments are:
    - Integrated with infrastructure planning and funding decisions; and
    - Strategic over the medium term and long term; and
- Responsive, particularly in relation to proposals that would supply significant development capacity.
- Local authorities have robust and frequently updated information about their urban environments and use it to inform planning decisions.
- New Zealand's urban environments:
    - Support reductions in GHG emissions; and
    - Are resilient to the current and future effects of climate change.

Urban environments are split into two tiers based on the size of the areas. Tier 1 urban environments include Auckland, Christchurch, Wellington, Tauranga and Hamilton and Tier 2 urban environments include Whangārai, Rotorua, New Plymouth, Napier-Hastings, Palmerston North, Nelson Tasman, Queenstown, and Dunedin.

Appendix C: Datasets and report reviews

Waka Kotahi datasets and research

TMS and RAMM

The TMS dataset consists of records of the AADT volumes from different time periods for sites along the State Highway network across New Zealand.

The RAMM dataset provides a range of data on roads across New Zealand. It is used as a primary transport asset repository for all Council owned and maintained assets and consists of observed and estimated traffic volumes at link/road level. The RAMM dataset also provides annual VKT estimates at TLA / regional level.

As part of this project, TMS data from continuous sites across the entire country was extracted for the past decade by Waka Kotahi. Estimated VKT for TLAs based on published RAMM data from 2002 to 2020 was provided by Waka Kotahi. This included 72 TLAs before the formation of the Auckland Council unitary authority ('supercity') in 2010 and 66 TLAs after that. Unfortunately, only a fraction of the data was split by vehicle class (light and heavy), so most of the VKT estimates from RAMM were for light and heavy combined.

Projected VKT

The Waka Kotahi Te Puna Taiao Baseline VKT Dataset consists of quarterly VKT estimates for total vehicles, light vehicles, buses, and heavy commercial vehicles. These estimates come from the Autoregressive Distributed Lag (ARDL) baseline VKT models developed by Waka Kotahi to model future VKT given no changes to current settings and policy directions. These ARDL models use quarterly VKT data from 2002 to 2019 from MoT for their respective land transport modes. Other input data to the models include GDP, labour force, exports, imports, and demographics, which were obtained from Statistics New Zealand.

The development of these models is discussed in a Waka Kotahi working paper that seeks to identify and develop interventions that could help reduce GHG emissions from land transport activities. To assess the effectiveness of such interventions it is necessary to develop VKT baselines for different modes and to forecast under current policy conditions. It is noted that it is necessary to reduce VKT by various land transport modes to reduce GHG emissions.

Emission model

The Vehicle Emissions Prediction Model (VEPM) has been developed by Waka Kotahi to predict emissions from vehicles in the New Zealand fleet under typical road, traffic, and operating conditions. The VEPM has been used to estimate vehicle emissions in air quality and GHG emissions assessments for New Zealand roading projects. The estimates provided by the VEPM are also suitable for regional emission inventories. An important feature of the model is the ability to estimate changes to vehicle emissions in future years.

The VEPM is an average speed model which predicts emission factors for the New Zealand vehicle fleet, based on different vehicle types and technologies present, and the relative kilometres travelled by each vehicle class. Fleet-weighted emission factors are calculated by multiplying the emissions factors for each vehicle class by the proportion of kilometres travelled by that class for any given year. The emission factor databases that the VEPM utilises to derive New Zealand relevant factors are constantly being updated with improved factors for new technologies, emerging issues, and real-world effects.

Emission dataset

The National Vehicle Emission Dataset (NVED) provides link level estimates for VKT and GHG emissions by vehicle type for 2019 and 2020. NVED estimates GHG emissions using the VEPM which accounts for traffic counts, fleet profile, speeds, temperatures, and gradients. The traffic count information used in the NVED is estimated from the RAMM dataset.

Ministry of Transport Datasets and Research

Observed VKT

There are two observed VKT datasets from Ministry of Transport. One is recorded quarterly from 2002 by 11 regions (referred to as quarterly observed data in this report), the other is in financial year from 2012/13 by 14 regions (referred to as regional observed data in this report). These datasets both come from vehicle odometer readings taken during vehicle fitness testing at WoF/CoF testing stations. Light VKT makes up the majority of VKT for every region in these datasets across all reported years.

The quarterly observed data is split by six vehicle types and assigned to 11 regions based on testing station location. The vehicle types include bus, heavy goods vehicle, light commercial vehicle, light passenger vehicle, motorcycle and miscellaneous. The 11 regions are based on aggregating the 16 regions of New Zealand. In which, Waikato, Bay of Plenty, West Coast and Otago are combined into one region (referred to as ‘Other’); and Tasman, Nelson and Marlborough are combined into another region (referred to as “Nelson/Marlborough”). The values are reported at a quarterly frequency from 2002 Q1 to 2021 Q2. Over this timeframe the Auckland, Canterbury, Nelson/Marlborough, Wellington, and ‘Other’ regions show significant percentage increases in light VKT, whereas the Gisborne and Northland regions show a decrease in light VKT.

The regional observed data is split by seven vehicle types and assigned to 14 regions based on the testing station location, also aligning closely with road use from Waka Kotahi’s RAMM data. The vehicle types include “Car+SUV excluding Taxi/Vehicle Share”, “Van+Ute excluding Taxi/Vehicle Share”, “Car+SUV Taxi/Vehicle Share only”, “Van+Ute Taxi/Vehicle Share only”, “Heavy Truck”, “Heavy Bus” and motorcycle. The 14 regions are based on aggregating the 16 regions of New Zealand. In which, Tasman, Nelson and Marlborough are combined into another region (referred to as “TNM”). The values are reported at financial year frequency from 2012/13 to 2018/19. Over this timeframe, every region shows an increase in light VKT, with Northland, Otago and Southland showing the largest percentage increases. At national level, the values are adjusted to reflect calendar year, but the same adjustment was not available for the version used in this research for regional estimates.

There is no way to quantify exactly what regions the vehicles have driven in compared to where they are fitness tested, so this may be a source of inaccuracy in these datasets.

Projected VKT

The Ministry of Transport projected VKT and vehicle number dataset consists of VKT and vehicle number estimates for five vehicle types across 14 regions. It provides projections for financial years from 2022/23 to 2057/58 in five-year increments. The projections are based on the transport outlook household travel model, which provides projection of household travel in person kilometres by various modes. Light VKT makes up the majority of VKT for every region in this dataset and every region except West Coast shows an increase in light VKT, with Auckland, Waikato, and Canterbury showing the largest percentage increases.

Emissions model

The Vehicle Fleet Emissions Model (VFEM) by Ministry of Transport projects the makeup of future vehicle fleets and their kilometres travelled, energy use and greenhouse gas emissions. Unlike the VEPM, the VFEM does not consider speed limits.

To project vehicle fleet mix in future years, the VFEM uses the historic vehicle fleet as the base data. The process works through each projection year to 2055, starting with the most recent, to determine the size and makeup of the future vehicle fleets.

The data includes the recent levels of vehicle scrappage and averages over the most recent three-year period to work out how many existing vehicles survive to the next modelled year.

The data includes the VKT and Vehicle Numbers Model projected vehicle numbers by type to work out how many vehicles of each type need to be registered into the fleet in the next projection year; the vehicles surviving scrappage plus the new registrations must match the projected vehicle numbers from the VKT and Vehicle Numbers Model.

The data includes the new and used import average mix in the last three years to split the new registrations that are needed into new and used imports.

The last component of the data includes the exogenously specified fleet feed-in mixes to determine the mix of vehicles that will be newly registered by their characteristics. There is a different feed in mix for each year from 2018 to 2055. This takes into consideration the number of electric and plug-in hybrid vehicles increases over time.

This data was used to create a range for the estimate based on the modelled vehicle fleets for each year.

Local Government Transport Models

Beca received the outputs for three regional transport models, these are for Auckland, Wellington, and Christchurch. Each of these three has slightly different characteristics but they all have the same purpose of providing an understanding of what traffic movements will look like in future scenarios and changes in land use.

Auckland

The Macro Strategic Model (MSM) dataset is the model output for the Auckland region. The model has data for 2018 and projections for 2038. The 2018 data can be compared to the MoT projection for 2018/19 and the Waka Kotahi RAMM 2020 data. The 2038 projection can be compared to the MoT projection for 2037/38.

The MSM is a higher order multi-modal transport demand model for the Auckland region. This model provides coarse vehicle and public transport assignments, with the primary purpose of understanding future transport demands. The Macro Public Transport Model (MPT) provides a more detailed public transport assignment for forecasting future public transport patronage. The Auckland Dynamic Traffic Assignment (ADTA) model similarly provides a more detailed vehicle assignment for region-wide dynamic traffic analysis.

The ADTA and MSM models cover the same extent of the Auckland region, encompassing Pukekohe to the south and Warkworth to the north. Two zones in the south outside of Auckland Council region (Tuakau and Pokeno) are also included in both models due to their proximity and interaction with Auckland.

Christchurch

The Christchurch Transportation Model (CTM) dataset is the model output for Christchurch. This model only covers the sub-regional area which includes the Christchurch city. The only comparable data for this transport model is the Waka Kotahi RAMM 2020 data.

The CTM is a four-stage model and is the main planning tool for the region. Forecast travel patterns are produced from input land use and the transport network. The four processes are:

- Trip end generation - the calculation of person trip ends by zone and purpose either 24 hour or for each period.
- Distribution - converting person trip ends into person trip matrices by purpose by means of some function of spatial separation of zones.
- Mode split - conversion of the person trip matrices for each mode type.
- Assignment - allocation of trip matrices by more to the road and public transport network.

Christchurch also has the Christchurch Assignment Simulation Traffic Model (CAST) sitting under the CTM which performs a similar function to the project models in other cities. In contrast to Auckland and Wellington, where the assignment models cover areas smaller than the strategic model, the CAST model covers the same area as the parent.

Wellington

The Wellington Transport Strategic Model (WTSM) dataset is the model output for the Wellington region. The 2018 data can be compared to the MoT projection for 2018/19 and the Waka Kotahi RAMM 2020 data. The 2036 projection can be compared to the MoT projection for 2037/38.

The WTSM uses the updated EMME network using road centreline GIS shape files and the information contained in the General Transit Feed Specification (GTFS) of the Wellington region. The GTFS contains information on all bus services and stop locations and is created from the Greater Wellington Regional Council (GWRC) Public Transport Database. The transit times for rail, cable car and ferry are ‘hard coded’ in both WTSM and Wellington Public Transport Model (WPTM) according to the published timetable. The actual performance of these modes understood to largely match the timetable, although some reliability is inevitable. An approach was selected that seeks to replicate actual bus run times in the base year and using the WTSM highway times as an explanatory variable.

WTSM and WPTM have been developed such that both models can be used as part of one ‘Transport Model System’ when it comes to future forecasting. Whilst there are subtle differences between both models, primarily due to WTSM being a strategic model and WPTM a more detailed public transport project model, both models use the same software package and operate using similar macros and assignment algorithms.

Statistics New Zealand Datasets and Research

Census

Census data provides the official count of people and dwellings in New Zealand every five years. The key data that comes out of the census includes population, age, sex, ethnicity, migration and dwelling number and occupancy.

Statistics New Zealand who undertakes the Census annually also conduct population projections for New Zealand as a whole, which is based on data from the previous census and calculated using a cohort-component method. These population projections take into consideration births, deaths, and net migration.

The data used for this project consists of 2018-base projections of the population usually living in selected territorial authority areas (cities and districts), and the statistical area 2 areas (SA2) they comprise. The population projects are based on boundaries at 1 January 2021.

These projections were supplied in 4-year age bands with a low, medium, and high population growth estimate for each. The low, medium, and high projections for each territorial authority area are from the Subnational Population Projections: 2018(base)–2048 released March 2021[8]. The working age group was defined in this report as the aggregation of the age bands between 16 and 65 years. Furthermore, the spatial definitions for SA2s, FUAs, TLAs, and Regions were used to define the spatial areas for subnation VKT and GHG emissions estimates in this report.

Other Datasets and Research

Ministry of Transport vehicle fleet data

The Ministry of Transport 2020 vehicle fleet dataset encompasses data on fleet composition, travel data, and some light vehicle emissions over the 2000 to 2020 period. This data can provide trends on vehicle numbers, vehicle types, and emissions for light vehicles in New Zealand which can be used to predict or model what may happen in future years.

Waka Kotahi national fleet

The Waka Kotahi New Zealand vehicle fleet is an open dataset that relates to currently registered vehicles as recorded on the Motor Vehicle Register. The available data stretches back into the 1900's and is updated monthly to reflect newly registered vehicles from the previous month. This dataset includes data on each vehicle such as the make and model, fuel type used, and year of registration in New Zealand.

Benchmarking Sustainable Urban Mobility

The Benchmarking Sustainable Urban Mobility provides an outline of the current transport situation in the five major centres of New Zealand (Auckland, Hamilton, Tauranga, Wellington, and Christchurch) and what plans each of the council organisations has for all modes.

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[8] https://www.stats.govt.nz/information-releases/subnational-population-projections-2018base2048

It has data on the share of each mode in each of the cities and the VKT per capita in each of the main centres. It outlines the proportion of total central city street space dedicated to sustainable urban mobility, level of service of the cycleways in each centre and average punctuality of bus services.

The input data to determine the Sustainable Urban Mobility outcomes include sustainable urban mobility plans, low carbon plans, maps and funding. These lead to the outputs of spatial distribution, infrastructure and service quality, access, travel concession passes and speed limits. The outcomes that have come from all of this include travel behaviour, travel behaviour by key audiences, environmental emissions, safety and cost and time.

It outlines the multimodal plans and targets, low carbon plans and emissions targets and walking, cycling and public transport plans for each of the five main centres.

It recognises the need for shifting towards sustainable modes of transport and the challenges that come with this. Councils are focusing on how their transport networks can enable change in the community, for the outcomes they are trying to achieve.