Build or maintain?

New Zealand's infrastructure asset value, investment, and depreciation, 1990–2022

February 2024

New Zealand Infrastructure commission / Te Waihanga

Te Waihanga seeks to transform infrastructure for all New Zealanders. By doing so our goal is to lift the economic performance of Aotearoa and improve the wellbeing of all New Zealanders.

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Cover image: Chris Sisarich, Ngatamariki power station

Cut to the chase

Today's choices determine tomorrow's infrastructure outcomes

The benefits that we experience from infrastructure today depend upon past decisions about how to plan, build, and maintain infrastructure assets. Similarly, our current decisions will affect the quality and quantity of infrastructure services for future generations.

However, infrastructure decision-makers face constraints: they cannot invest in everything, so they must choose how much to spend on new assets to improve levels of service, how much to spend on new assets to meet additional demand, and how much to spend on maintaining and renewing existing assets.

The costs and benefits of these choices vary over time. Maintaining and renewing existing assets might appear to have few short-term benefits but it is essential in the long term. On the other hand, building new infrastructure often seems more visible and important in the short term.

To help navigate these choices, we need a better understanding of the infrastructure we already have, how much we are investing in our infrastructure networks, and how fast they are wearing out or becoming obsolete.

A comprehensive and consistent picture of infrastructure capital

This *Research Insights* paper provides the first comprehensive and consistent view of the financial value of New Zealand's infrastructure assets, how much we are investing in our infrastructure, and how fast they are wearing out. It also considers whether current rates of renewal investment are sufficient to keep up with depreciation.

We cover all types of infrastructure assets, regardless of whether they are owned by central government, local government, or commercial or private-sector operators. We report data for both horizontal infrastructure sectors (transport, electricity/gas, water/waste, and telecommunications infrastructure) and vertical infrastructure sectors (education; hospitals; public administration and safety, including defence; social housing; and other types of public capital).

We use data from Statistics New Zealand's annual National Accounts, which provides a comprehensive, economy-wide view on capital assets. This data covers the period from 1990 to 2022.

Key terms

Asset value: This reflects the current value of fixed assets, or durable assets with a lifespan of more than one year. It includes built assets like roads and pipes as well as equipment and machinery and IT systems, but excludes the value of land used for infrastructure. Also called 'net capital stock'.

Investment: This reflects annual capital investment in durable assets. Also called 'gross fixed capital formation'.

Depreciation: This is a financial estimate of normal wear and tear on infrastructure and obsolescence due to technological changes. It excludes damages from natural disasters and other infrequent events. Also called 'consumption of fixed capital'.

Our key findings

1 **The value of our infrastructure assets is rising over time**	The inflation-adjusted value of New Zealand's infrastructure assets rose from $32,900 per person in 1990 to $55,800 per person in 2022. In 2022, our infrastructure assets, excluding land, were valued at $287 billion. 45% of this infrastructure is owned by central government, 26% is owned by local government, and 29% is commercially or privately owned. Infrastructure assets have significant benefits for society, but they must be maintained, renewed, and repaired to ensure that they continue to provide those benefits – which requires adequate funding.
2 **Current investment rates signal likely future investment levels**	Between 2003 and 2022, infrastructure investment averaged 5.8% of GDP. We spent an average of 3.4% of GDP on horizontal infrastructure and 2.4% on vertical infrastructure. Investment rates fluctuate slightly from year to year but have not trended up or down. Current investment levels reflect a balance between the benefits that we perceive from more infrastructure and our willingness to pay taxes, rates, or user charges to fund it. Sustaining higher investment would require us to increase taxes, rates, or user charges, while lower investment would require us to accept less or lower-quality infrastructure.
3 **Around 60% of investment needs to go to renewing existing assets, not building more**	Between 2013 and 2022, depreciation costs for infrastructure were equal to 58% of new capital investment. For every $10 we spent on new infrastructure, almost $6 of existing infrastructure wore out. If we want to maintain our existing infrastructure for future generations, that's roughly how much we need to spend on renewal investment. That leaves $4 out of every $10 of investment available for new or improved infrastructure. Required renewal ratios are slightly lower for horizontal infrastructure (52%) and slightly higher for vertical infrastructure (67%), as horizontal infrastructure assets tend to be longer-lived.
4 **We may not be spending enough to renew our infrastructure assets**	The available data suggests that renewal spending for electricity distribution infrastructure and existing flood protection infrastructure equals or exceeds depreciation. However, renewal spending is below depreciation for state highways, local roads, water supply, wastewater and stormwater infrastructure, and gas distribution infrastructure. In the case of state highways and local roads, we also show that this has led to declining asset condition. We could not find comparable data on vertical infrastructure, as central government, which owns most of these assets, does not compile and publicly report this data.

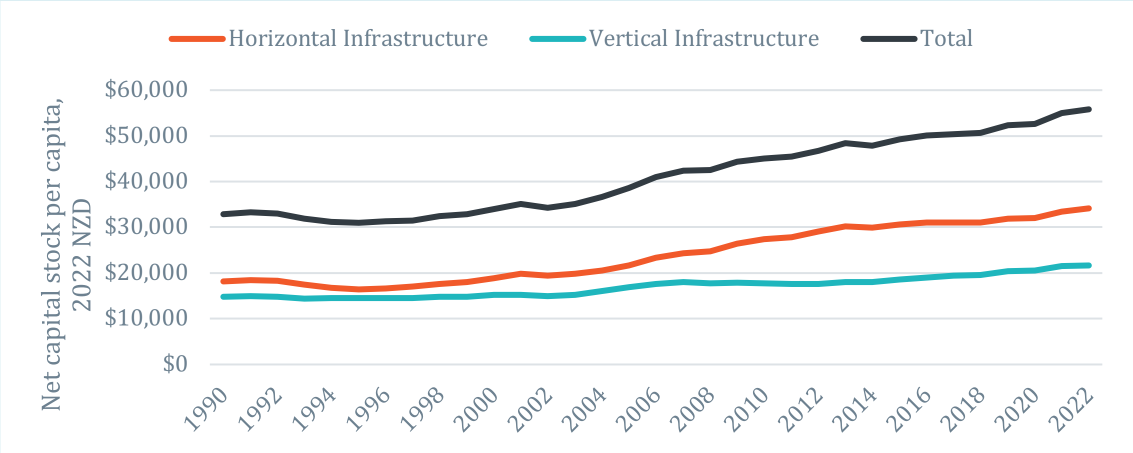
In depth: The value of our infrastructure assets

Figure 1 shows how the per-capita value of horizontal and vertical infrastructure assets has changed over time. Adjusted for inflation, the value of infrastructure assets rose from $32,900 per person in 1990 to $55,800 per person. This suggests that we have 70% more infrastructure per person than we did a generation ago.

Increases in the value of infrastructure assets reflect several factors, including investment in new and improved infrastructure, increases in the benefits that people receive from existing infrastructure, and revaluations due to the rising cost to build infrastructure assets.

The value of horizontal infrastructure has risen more rapidly than the value of vertical infrastructure. The rising value of horizontal infrastructure is mainly driven by increased investment in transport and water infrastructure.

Figure 1: Real per-capita value of New Zealand's infrastructure assets, 1990–2022



In 2022, our infrastructure assets, excluding land, were worth a total of $287 billion.

Central government is the largest asset owner, with 45% of total infrastructure assets. Transport infrastructure (mainly the state highway network) accounts for one-third of central government's infrastructure assets. Education infrastructure (schools and universities) also accounts for one-third. The remaining one-third comprises hospitals, public administration and safety infrastructure (courts, prisons, and defence assets), and social housing.

Local government owns 26% of New Zealand's total infrastructure assets. Transport infrastructure (mainly local roads) accounts for over 40% of local government's infrastructure assets. Water and waste infrastructure accounts for a further 30%. The remaining assets comprise public administration infrastructure, social housing, and other forms of public capital like libraries, stadiums, and convention centres.

The remaining 29% of infrastructure assets are owned by commercial or private-sector providers. Electricity and gas infrastructure accounts for more than half of these assets. Telecommunications infrastructure accounts for a further 25%. The remaining assets are spread across waste infrastructure, education infrastructure, and hospitals.

In depth: New Zealand's capital investment in infrastructure

While infrastructure investment briefly declined in the 1990s, our overall rate of infrastructure investment has been consistently higher since then. Figure 2 shows that, between 2003 and 2022, gross fixed capital formation in infrastructure ranged between 5.0% and 6.5% of GDP, with an average of 5.8%.

On average, we have invested around 3.4% of GDP in horizontal infrastructure, like transport, water, electricity, and telecommunications, and 2.4% in vertical infrastructure, like schools, hospitals, and public safety and defence. Because we are investing a roughly constant share of GDP in infrastructure, and because GDP is rising over time, the dollar value of infrastructure investment is rising both in total and in per-capita terms.

Figure 2: Infrastructure capital investment as a share of GDP, 1990–2022

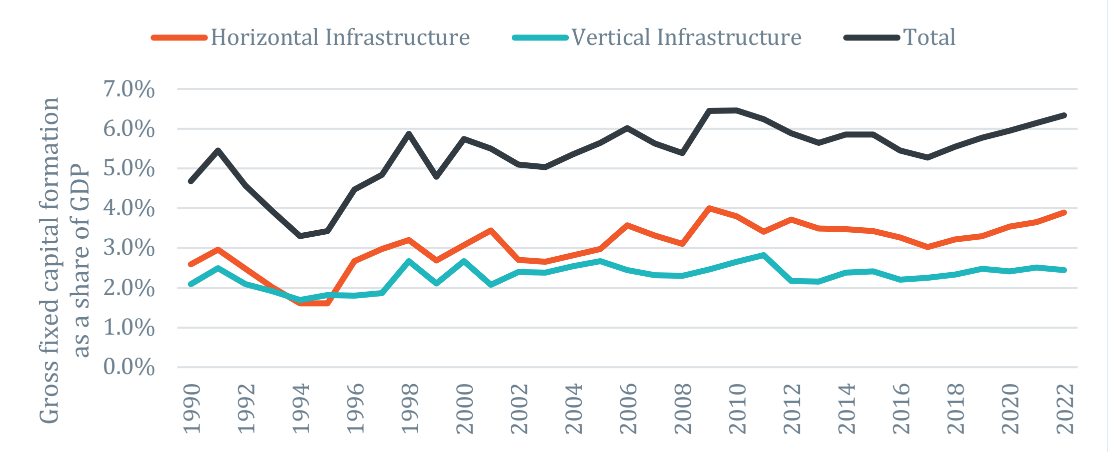
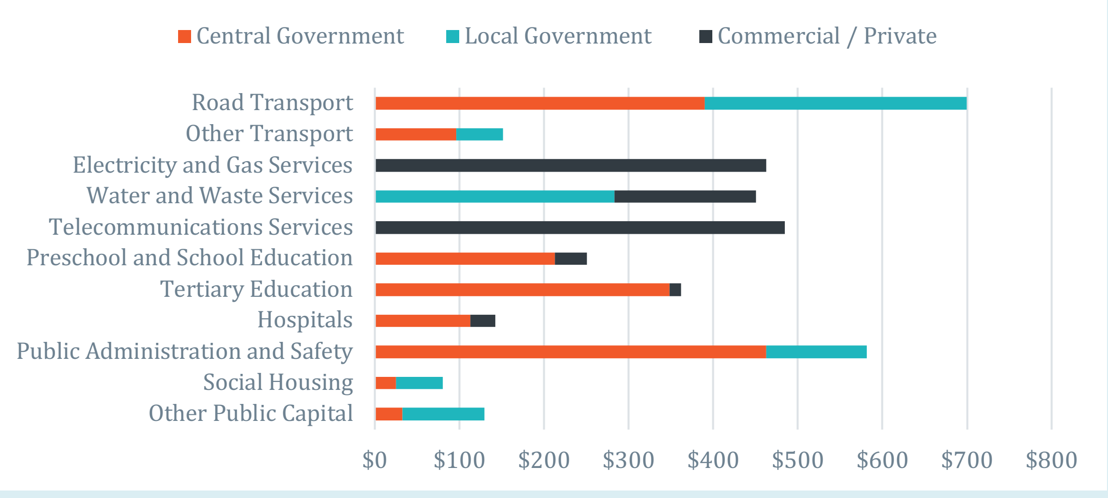


Figure 3 shows average annual investment, per person, in different infrastructure sectors over the 2013–2022 period. During this time, we invested an average of $3,780 per capita, per year. Road transport was the largest single investment category, averaging around $700 per capita. We invested around $450–$480 per person in electricity and gas infrastructure, water and waste infrastructure, and telecommunications infrastructure. Investment in school infrastructure ($250 per capita) and university infrastructure ($360 per capita) exceeded hospital investment ($140 per capita), despite a trend towards an ageing population.

Figure 3: Average annual real per-capita value of gross fixed capital formation, 2013–2022



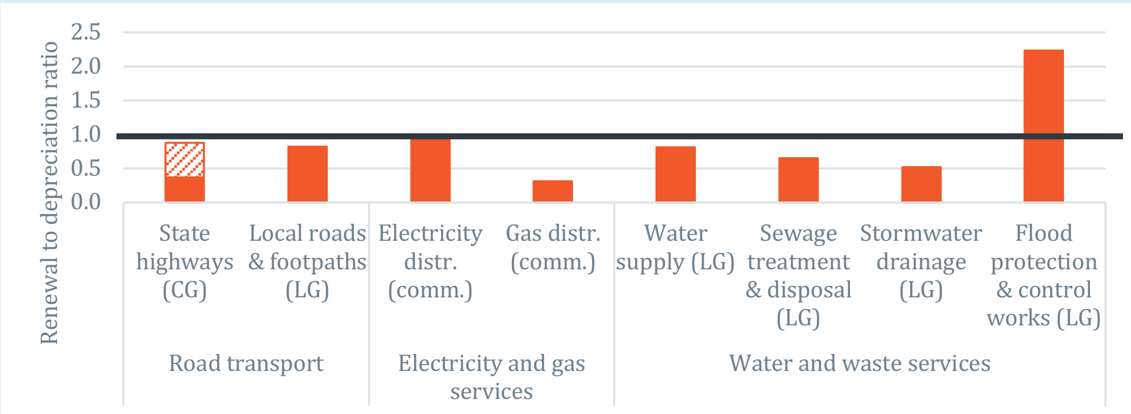
Note: Social housing GFKF data not available for the years 2020–2022

In depth: The sufficiency of renewal investment

As long as we expect to continue to need our current infrastructure, we need to spend enough to keep it in good condition. Statistics on depreciation costs for infrastructure suggest that we need to spend around 60% of current investment on renewal of existing assets to achieve this. However, actual renewal spending may not be sufficient.

Figure 4 shows the ratio of renewal investment to depreciation costs for three types of horizontal infrastructure. Ratios below one, indicating that renewal investment is lower than depreciation costs for a multi-year period, indicate that renewal spending may not be sufficient. Renewal ratios are close to or above one for flood protection infrastructure (following previous underinvestment in renewals) and electricity distribution infrastructure, but significantly below one for state highways; local roads; water, wastewater, and stormwater infrastructure; and gas distribution (where demand is expected to decline in the future).

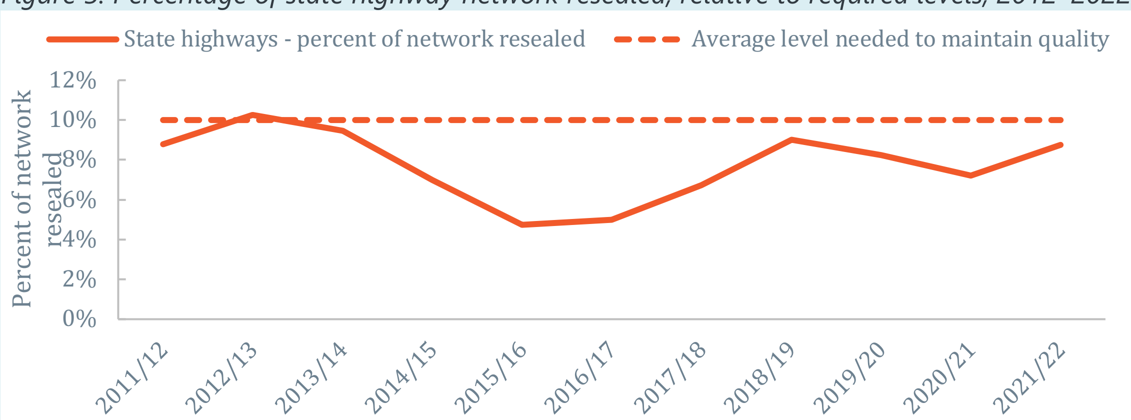
Figure 4: Renewal to depreciation ratios for selected infrastructure sectors



Source: Te Waihanga analysis of data published by infrastructure providers and regulators. The dashed bar for state highways indicates alternative assumptions about the classification of renewal vs maintenance spending.

More detailed analysis is needed to understand whether low spending on renewals is causing asset condition to decline. For example, Figure 5 shows that insufficient state highway renewal funding led to declining pavement reseals in the early 2010s. Funding and renewal activity rebounded in 2018 but has remained too low to fully achieve required resealing rates. As a result, the average condition of pavement surfaces has gradually declined over the last decade, especially in low-traffic parts of the network.

Figure 5: Percentage of state highway network resealed, relative to required levels, 2012–2022



Contents

Glossary of terms

Term	Definition
Asset maintenance	Asset maintenance is a type of operational expenditure. There are two types of maintenance: proactive and reactive. Proactive maintenance is work done ahead of time to prevent deterioration in asset condition. For example, proactive maintenance of a roof could include cleaning the gutters or repainting the roof. Reactive maintenance is work done in response to asset damage or failure. An example is fixing a leak in the roof when one appears.
Asset renewal	Asset renewal is a type of capital expenditure that involves replacing assets that are at the end of their life. For example, replacing the roof of a house once it is at the end of its life.
Asset value	Asset value reflects the current value of fixed assets, or durable assets with a lifespan of more than one year. It includes built assets like roads and pipes as well as equipment and machinery and IT systems but excludes the value of land used for infrastructure. Also called 'net capital stock'.
Australian and New Zealand Standard Industrial Classification (ANZSIC)	This classification is used in the compilation and analysis of industry statistics in Australia and New Zealand. It categorises all organisations that trade or employ people into industries based on what types of activities they do. Industry statistics can be grouped and reported at varying levels of detail.
Consumption of fixed capital (CFK)	This is a measure of depreciation, that is, the decline in the value of fixed assets as the result of normal physical wear and tear, normal obsolescence, or normal accidental damage. CFK also includes declines in asset values because of a decrease in the demand for their services. CFK does not include losses that are due to extreme events such as wars or natural disasters.
Depreciation	Depreciation is the decrease in the value of an asset over time. There are two aspects to this concept. The first is the actual reduction in the value of an asset as it is used and wears, and the second is the accounting practice of allocating the original cost of an asset to the periods in which the asset will be used. In this paper we are referring to the first aspect of depreciation, physical deterioration due to use.
Fixed assets	Fixed assets are assets that are used repeatedly, or continuously, in processes of production for more than one year.
Gross fixed capital formation (GFKF)	This is a measure of capital investment, that is, the value of new additions to the fixed capital stock minus disposals of existing assets. Here 'new' means new to the New Zealand economy and therefore includes second-hand assets imported from overseas. GFKF also includes upgrade and renovation expenditures that significantly extend an asset's useful life.
Horizontal and vertical infrastructure	The terms 'horizontal' and 'vertical' refer to the spatial property of the type of infrastructure. Horizontal infrastructure is generally network infrastructure – such as water pipes – and is therefore more spread out. Vertical infrastructure assets are typically large buildings – such as hospitals – and therefore occupy more vertical space rather than being spread out.

Investment	Investment reflects annual capital investment in durable assets. It is also called 'gross fixed capital formation'.
Net capital stock (NKS)	This is the depreciated value of fixed assets held by producers in the economy. NKS is valued at replacement cost, meaning it should reflect how much it would cost to replace the existing assets with similar condition assets. NKS is comparable to the 'depreciated replacement cost' accounting method of valuation.

Introduction

We need to know what we already have to help us choose what to do next

Infrastructure providers use fixed assets, like water treatment plants or hospitals, to deliver services, like supply of clean drinking water or surgical care, to people.

The benefits that we experience from infrastructure services today depend upon past decisions about how to plan, build, and maintain infrastructure assets. Similarly, our current decisions will affect the quality and quantity of infrastructure services for future generations.

However, infrastructure decision-makers face constraints: they cannot invest in everything, so they must choose how much to invest in new assets to improve levels of service, how much to invest in new assets to meet additional demand, and how much to invest in renewing existing assets.

The costs and benefits of these choices vary over time. Maintaining and renewing existing assets might appear to have few short-term benefits but it is essential in the long term. On the other hand, building new infrastructure often seems more visible and important in the short term.

To help navigate these choices, we need a better understanding of the infrastructure we already have, how much we are investing in our infrastructure networks, and how fast they are wearing out or becoming obsolete.

The overall value of infrastructure assets changes over time

The financial value of infrastructure assets changes over time.

When the overall value of infrastructure assets increases, it generally means that they can provide more or better services to users. Decreases in value mean that their ability to provide services is reducing. However, there are four main ways that the value of our infrastructure can change.

We can build more infrastructure or renew existing infrastructure

Investment in building or renewing infrastructure increases the total value of infrastructure assets. This is because it creates new infrastructure assets or increases the value of existing assets by improving the quality of those assets or renewing them to increase their lifespan.

The demand for existing assets' services can increase (or decrease)

When demand for the services provided by an infrastructure asset increases, the value of that asset increases to reflect this. For instance, an increase in demand for electricity that leads to an increase in electricity prices would increase the value of electricity generation assets like wind farms and hydroelectric dams.

The same thing can also happen in reverse: If technological changes or development of new infrastructure options reduce demand for an existing asset, then the value of that asset will decline. For instance, recently developed ultrafast broadband infrastructure is likely to have reduced the value of existing copper telecommunications infrastructure because it is a higher-quality substitute.

This is most relevant for the value of infrastructure assets that operate in a commercial or market-based context, such as electricity generation or telecommunications. Central and local government infrastructure assets are unlikely to be revalued to reflect changes in demand, because there is no competitive market for infrastructure services from which to derive a market price. Infrastructure assets that are regulated by the Commerce Commission, like electricity transmission and distribution, are valued based on the value of the regulated asset base.[1] A regulated business is only allowed to recover from consumers the value of the regulated asset base plus the regulated cost of capital, regardless of what demand does.

Existing assets can wear out

While infrastructure assets are durable, they wear out due to use, weather damage, and other factors. The value of existing infrastructure assets therefore decreases over time to account for the ongoing depreciation of these assets.

Maintenance and renewal investment can offset depreciation, allowing assets to continue to function. In the absence of renewal investment, the condition of infrastructure assets will decline over time and eventually reach a point of failure.

The cost to construct the assets can increase

The value of infrastructure assets is often measured based on 'depreciated replacement cost' of those assets. This is the amount that would have to be spent today to replace the asset with a similar asset that is in similar condition.

What this means is that increases in the cost to build new infrastructure result in increases in the estimated value of existing infrastructure assets, even though there has been no increase in quality, quantity, or utilisation. We know from past research that the cost to build infrastructure is rising over time, due to a combination of slower productivity growth for infrastructure construction, increases in the cost of inputs like labour, materials, and land, and changes in design standards and project scope (New Zealand Infrastructure Commission, 2022a, 2022b, 2023).

Unlike increases in infrastructure asset values due to investment or increased demand, increases due to rising construction costs are unlikely to provide value to society. Higher construction costs mean it is becoming more costly to maintain and renew infrastructure. This in turn means that the economically optimal amount of infrastructure is lower (New

[1] https://comcom.govt.nz/regulated-industries

Zealand Infrastructure Commission, 2021). The value society gains from these assets will decrease as the cost to build and renew them increases.

A comprehensive and consistent picture of infrastructure capital

This *Research Insights* paper provides the first comprehensive and consistent view of the value of New Zealand's infrastructure assets, how much we are investing in our infrastructure, and how fast they are wearing out. It also considers whether current rates of renewal investment are sufficient to keep up with depreciation.

In this paper, we focus on the supply of infrastructure – how much we have and how much we are investing in it. However, more infrastructure is not necessarily better. To assess whether we have the right amount of infrastructure, or the right type of infrastructure, we need to know more about demand for infrastructure, including people's willingness to pay for more or better infrastructure. Building too much infrastructure when there is little demand for it will not help to address our infrastructure needs.

Our analysis builds upon our previous work, including:

- Our 'State of Play' reviews of New Zealand's infrastructure sectors, which outline the key features and challenges facing each sector.
- Sense Partners' (2021) report on *New Zealand's infrastructure challenge*, which Te Waihanga commissioned to examine historical investment by central and local government and estimate the scale of future infrastructure challenges.[2]
- Our *Research Insights* report entitled *Investment gap or efficiency gap?*, which benchmarks New Zealand's public infrastructure investment and infrastructure quality against other high-income countries (New Zealand Infrastructure Commission, 2021).
- Our *Research Insights* report entitled *How much do we pay for infrastructure?*, which analyses New Zealand's households' spending on network infrastructure services, including the cost of providing infrastructure and using it (New Zealand Infrastructure Commission, 2023).

A common source of data: Statistics New Zealand's National Accounts

We construct a consistent and comprehensive picture of the financial value of New Zealand's infrastructure assets using a custom data request from Statistics New Zealand's (Stats NZ's) annual National Accounts.[3] Stats NZ's System of National Accounts is based

[2] https://tewaihanga.govt.nz/our-work/research-insights/new-zealand-s-infrastructure-challenge-quantifying-the-gap-and-path-to-close-it

[3] Stats NZ already publishes relevant data broken down by ANZSIC industry and sector of ownership (central government, local government, and non-government). Our custom request cross-tabulated this data by both ANZSIC industry (either at the 1-digit or 2-digit industry level, depending upon industry) and sector of ownership. This data allows us to develop and report measures for specific infrastructure sectors, broken down by ownership where relevant. Appendix 2 describes how we used ANZSIC industry and sector of ownership to define infrastructure sectors.

on an internationally standardised methodology for measuring the economic activity of a nation (United Nations et al., 2009).[4]

The most well-known National Account statistic is gross domestic product (GDP), which is used to measure the size and growth rate of the New Zealand economy. In addition, the National Accounts also include data on asset values, capital investment, and depreciation in different parts of the economy. This data is available annually for the 1990–2022 period.

There are three key advantages of using Stats NZ data, rather than information sourced directly from infrastructure providers. First, it is comprehensive, covering all types of infrastructure and both government and commercial/private-sector infrastructure. No other source is as comprehensive, as different infrastructure sectors publicly disclose different types of information about their assets and investments. Second, it is based on a consistent set of definitions, making it possible to compare across all types of infrastructure. Third, while this paper is not focused on international comparisons, it would enable these comparisons in the future as National Accounts statistics are designed to be comparable between countries.

Because Stats NZ's National Accounts are based on financial data provided by asset owners, the data that we present should line up with infrastructure providers' own estimates of their asset value and investment. However, infrastructure providers sometimes have a slightly different view about the value of their assets, as they may use different valuation methodologies or have more detailed information on the condition, lifespan, or cost of their assets. Appendix 3 illustrates this in the case of state highways.

Moreover, the current value of infrastructure assets may not be a good guide to what it would cost to rebuild or replace infrastructure, for instance, following a natural disaster. Costs may rise due to increases in labour or material costs for infrastructure projects, or changing design standards that require us to build higher-quality but more expensive infrastructure than we used to.

Measuring infrastructure capital: NKS, GFKF, CFK

We use Stats NZ's National Accounts data to measure three key financial indicators for New Zealand's infrastructure:

- **Net capital stock (NKS)**: This reflects the current value of infrastructure assets in terms of depreciated replacement cost (that is, accumulated investment, minus accumulated depreciation), excluding land. This is our key measure of **asset value**.
- **Gross fixed capital formation (GFKF)**: This reflects annual capital investment in durable assets. For the sectors that we are analysing, most capital investment (and hence most capital stock) relates to built assets, like roads, pipes, and buildings, but this also includes investment in equipment and machinery and IT systems. This is our key measure of **capital investment**.

[4] For more details on how Stats NZ calculates the capital account figures, see *System of National Accounts* (United Nations et al., 2009) and *Measuring capital stock in the New Zealand economy* (Statistics New Zealand, 2014). Appendix 1 summarises key elements of these calculations.

- **Consumption of fixed capital (CFK)**: This is a financial estimate of annual wear and tear on infrastructure and obsolescence due to technological changes.[5] This is our key measure of **depreciation**.

Stats NZ provides data on each measure in nominal (non-inflation-adjusted) New Zealand dollars. We normalised data on NKS, GFKF, and CFK in three different ways:

- **Real (inflation-adjusted) New Zealand dollars**: We adjusted historical values to 2022 New Zealand dollars using a GDP deflator. This allows us to see how asset values, capital investment, and depreciation have changed over time, adjusting for inflation.
- **Relative to GDP**: We compared annual data to the overall size of the New Zealand economy in that year. This allows us to see, for instance, what share of our national income we have invested in infrastructure over time.
- **Relative to population**: We calculated inflation-adjusted asset values for each year and divided them by the total New Zealand population in each year. This allows us to see how the per-capita value of infrastructure assets has changed over time.

We also calculated some supplementary measures, such as the ratio of CFK to NKS, which is an estimate of the average depreciation rate for different infrastructure sectors. In addition, we use data sourced directly from selected infrastructure owners and regulators to understand how investment in asset management and renewal compares with depreciation on fixed assets.

Defining infrastructure assets using National Accounts data

Stats NZ's National Accounts data provides information on 'fixed assets', which are durable assets that have a lifespan of more than one year. For the sectors that we are analysing, most fixed assets are built assets, like roads, pipes, and buildings, but this definition also includes investment in equipment and machinery and IT systems.

The shaded boxes in Table 1 indicate what types of assets are included in the various measures. A key point is that Stats NZ's measure of net capital stock does not include natural assets such as land. However, infrastructure providers typically count land as a fixed asset in their own financial accounts. Land is not considered to depreciate over time and can therefore comprise a substantial portion of the book value of an infrastructure provider's fixed assets. As shown in Appendix 3, this means that the book value of an infrastructure provider's fixed assets can be higher than the net capital stock value we report here.

[5] Consumption of fixed capital does not include decreases in asset values that are the result of extraordinary events. CFK only includes physical deterioration, normal obsolescence, or normal accidental damage. Damages to assets due to events such as wars and natural disasters are therefore not included. However, losses due to extraordinary events are reflected in the NKS figures. The losses are recorded in a separate 'other changes in volume of assets' account, rather than in the CFK account.

Table 1: What's included in the capital accounts?

	Non-produced assets		**Produced assets**	
	Tangible assets	**Intangible assets**	**Tangible fixed assets**	**Intangible fixed assets**
Gross fixed capital formation (GFKF)	Land improvements and transfer costs.	Transfer costs (added to underlying asset).	Constructed physical assets used in processes of production for more than one year.	In practice, the only intangible fixed assets included are 'oil and gas exploration' and 'computer software' due to lack of suitable data.
Consumption of fixed capital (CFK)				
Net capital stock (NKS)	Not included as the major improvements to non-produced natural assets become part of the value of the natural asset itself once they are completed. Natural assets such as land are not included in NKS.			

Defining infrastructure sectors

In this paper, we report data in three main ways.

- First, we report data by sector of ownership, split up into central government, local government, and commercial/private sector infrastructure (including trading organisations owned by central or local government).
- Second, we report data for 'horizontal' infrastructure and 'vertical' infrastructure as a whole.
- Third, we report data at the broad infrastructure sector level, for instance distinguishing between transport infrastructure and electricity/gas infrastructure.

Table 2 shows the categories that we use throughout the report. More detailed breakdowns are available in the associated data book.

Table 2: Categorising infrastructure sectors

Type of infrastructure	**Infrastructure sector**
Horizontal infrastructure	Transport
	Electricity and Gas
	Water and Waste
	Telecommunications
Vertical infrastructure	Education
	Hospitals
	Public Administration and Safety (including defence)
	Social Housing
	Other Public Capital

Note: Appendix 2 provides further detail on the definition of these categories.

The value of New Zealand's infrastructure assets

In this section, we use Stats NZ's net capital stock data to understand how much New Zealand's infrastructure assets (excluding land) are currently worth and how the overall value of our infrastructure assets has changed over time. We break the figures down by sector of ownership and by type of infrastructure.

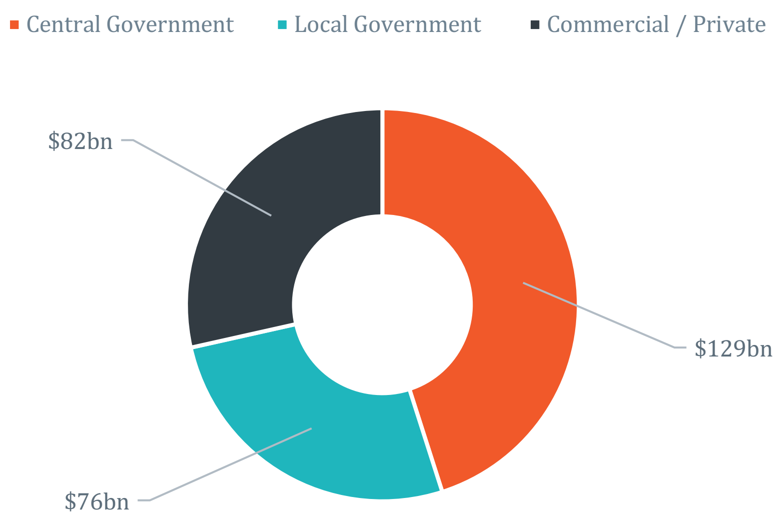
The value of infrastructure assets in 2022

Summary by sector of ownership

Figure 6 shows net capital stock of infrastructure by sector of ownership in 2022.[6] In total, Stats NZ's capital account figures estimate that New Zealand's infrastructure is worth around $287 billion. This is equal to $55,800 per New Zealander. $129 billion (45%) of this infrastructure is owned by central government, $76 billion (26%) is owned by local government, and $82 billion (29%) is commercially and privately owned.

The value of New Zealand's total net capital stock (not just infrastructure) is $1,110 billion in 2022.[7] Therefore, infrastructure assets comprise just over a quarter of all fixed capital assets in the New Zealand economy.

Figure 6: Infrastructure net capital stock by sector of ownership, 2022



Summary by infrastructure network

[6] Years for the Stats NZ NKS, GFKF, and CFK figures refer to the financial year ended March of that year.
[7] https://www.stats.govt.nz/information-releases/national-accounts-income-and-expenditure-year-ended-march-2022/

Figure 7 below shows net capital stock for horizontal infrastructure sectors. Road transport infrastructure is the single largest category, valued at $67 billion. Ownership is roughly evenly split between central government (state highways, worth $37 billion) and local government (local roads, worth $30 billion).

Other transport infrastructure is valued at $8 billion NZD. Other transport includes rail, water, air, and other transport infrastructure. A quarter of this figure ($2 billion) is rail infrastructure assets owned by KiwiRail.

Electricity and gas infrastructure and telecommunications infrastructure are the two big commercially owned infrastructure sectors. Electricity and gas infrastructure assets are valued at nearly $47 billion and telecommunications infrastructure assets are valued at over $20 billion.

Water, sewerage, drainage and waste service infrastructure assets are mostly owned by local government and partly owned commercially and privately. Local government water and waste infrastructure assets are valued at over $23 billion and commercial or private assets are valued at nearly $10 billion.

Figure 7: Dollar value of New Zealand's horizontal infrastructure assets, 2022

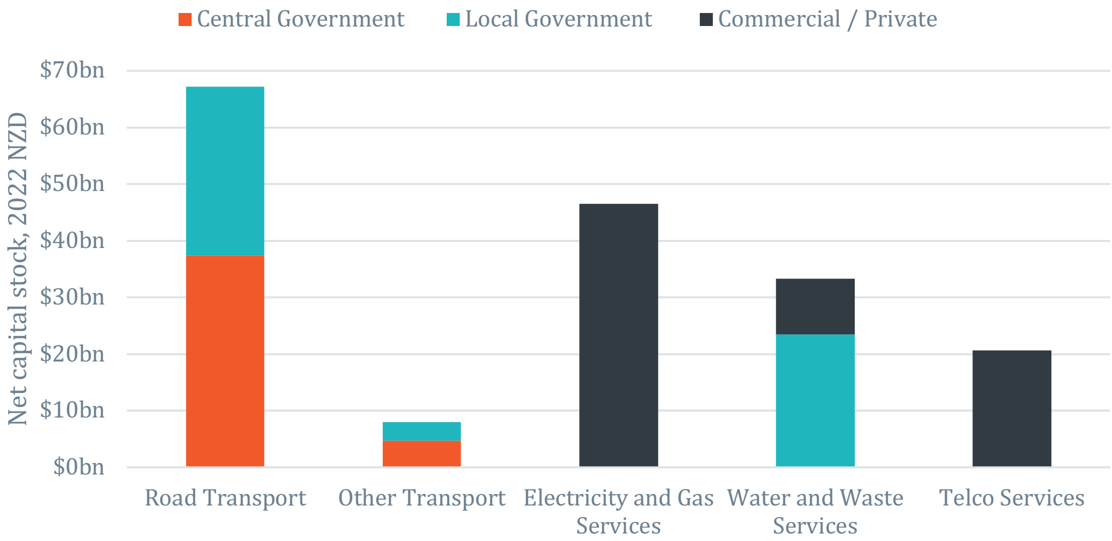


Figure 8 below shows net capital stock for New Zealand's vertical infrastructure sectors. Preschool and school education infrastructure owned by central government is worth approximately $25 billion NZD. There is a small amount of privately owned education infrastructure worth $2.6 billion.

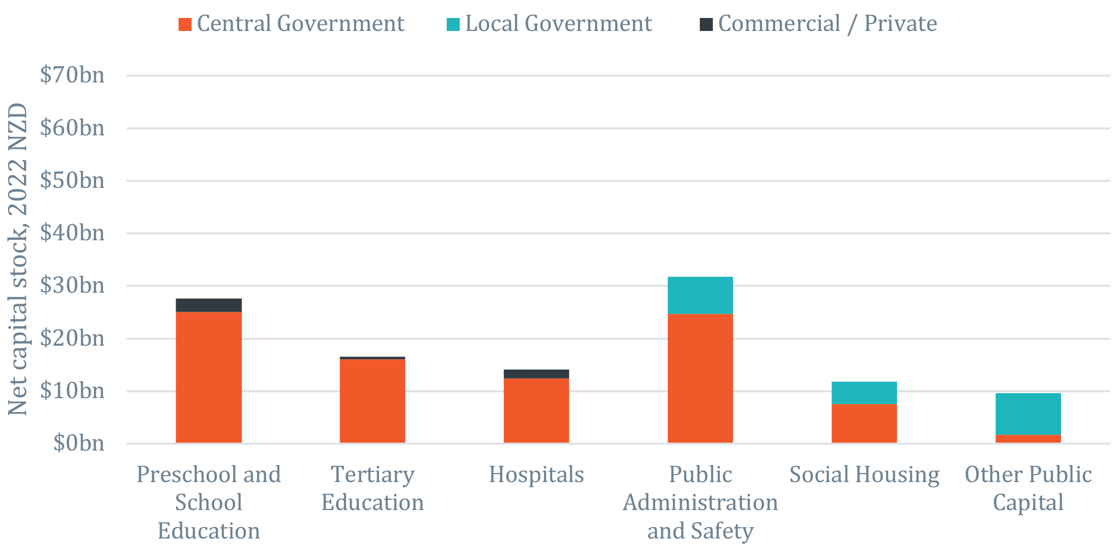
Tertiary education infrastructure owned by central government is worth $16 billion and there is a small amount of privately owned tertiary education infrastructure worth $0.4 billion. Hospital infrastructure owned by central government is worth $12 billion and privately owned hospital infrastructure is worth $1.8 billion.

The public administration and safety category includes government administration assets, defence infrastructure, justice infrastructure, and public order and safety services infrastructure such as fire stations and police stations. Central government public administration and safety infrastructure is valued at nearly $25 billion and local government public administration and safety infrastructure is valued at $7 billion.

Social housing infrastructure owned by the central government is worth $7.5 billion and social housing infrastructure owned by local government is worth just over $4 billion.[8]

The 'other public capital' category includes telecommunications, internet, and library services infrastructure, social assistance infrastructure, and arts, recreation, and other service infrastructure. Local government owns infrastructure worth nearly $8 billion in the other public capital category. Central government owns other public capital infrastructure worth just over $1.6 billion.

Figure 8: Dollar value of New Zealand's vertical infrastructure assets, 2022



Changes in the value of infrastructure over time

As noted in the introduction, asset values can increase for different reasons. There can be an increase in actual investment and therefore the asset base, there can be an increase in demand for the assets, or there can be an increase due to increasing asset replacement costs.

We analyse changes in value of infrastructure between 1990 and 2022. First, we show the real (inflation-adjusted) value of infrastructure over time, adjusting historical values to 2022 dollars.[9] This shows us how much the overall value of infrastructure assets is

[8] Kāinga Ora values their buildings at $14 billion in their 2021/22 annual report. This is higher than the central government figure present in the National Accounts. Most of Kāinga Ora's portfolio value comes from the land their properties are on, $29.9 billion. Depreciation charged on their rental properties for the 2021/22 financial year was $389 million, which is in line with the CFK figure for 2022.

[9] Values are inflation adjusted using the economy-wide GDP(P) inflator from Stats NZ: https://www.stats.govt.nz/indicators/gross-domestic-product-gdp/. There are capital goods price indices published by Stats NZ, but it is not straightforward to align these with the infrastructure sectors. Any given sector will have a mix of assets that all have different price deflators.

increasing over time, after controlling for increases that are due to economy-wide inflation.

Second, we show the value of infrastructure as a percentage of GDP. This shows us whether the value of infrastructure assets is keeping pace with the overall size of the economy.

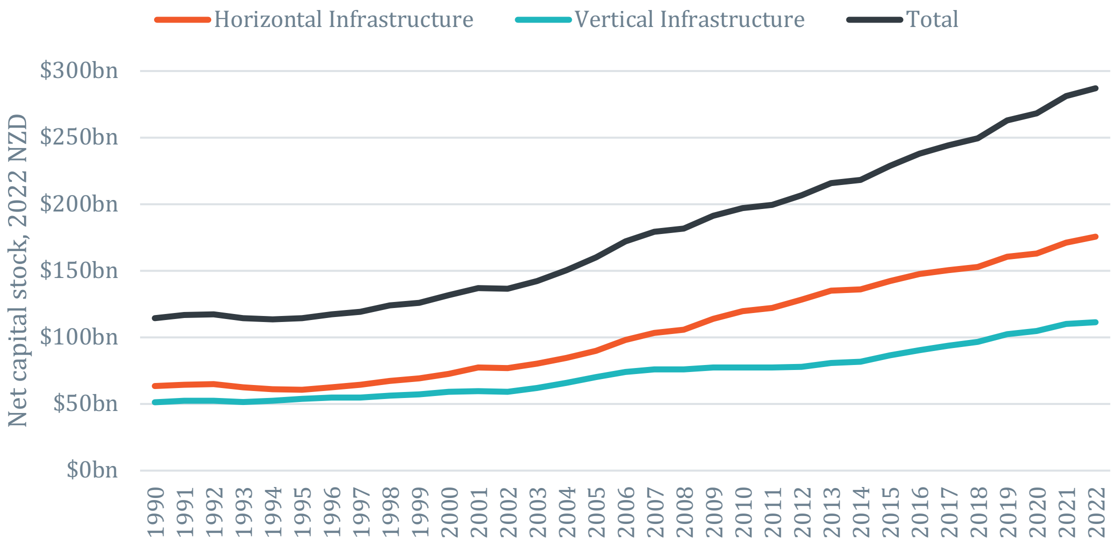
Third, we show the real (inflation-adjusted) value of infrastructure assets per capita. This shows us whether the quantity and quality of infrastructure per person is generally increasing or decreasing over time.

As context for this analysis, we note that New Zealand government departments experienced major reforms in the late 1980s and early 1990s. A part of this reform was the shift to full accrual accounting and recording of property, plant and assets. This means increasing infrastructure asset values in the early 1990s may be partly due to existing assets being added to the accounting books or valued in a different way, rather than actual new assets being purchased or constructed.

The value of infrastructure assets in real terms

Figure 9 shows the total value of New Zealand's infrastructure assets from 1990 to 2022 in 2022 dollars. Horizontal infrastructure was worth $63 billion in 1990 and vertical infrastructure was worth $52 billion. The inflation-adjusted value of horizontal infrastructure has grown faster than the value of vertical infrastructure, particularly since the mid-2000s. In 2022, horizontal infrastructure was worth $176 billion, which is an increase of 178%. The value of vertical infrastructure grew to $111 billion in 2022, an increase of 117%.

Figure 9: Value of New Zealand's infrastructure assets in 2022 dollars, 1990–2022



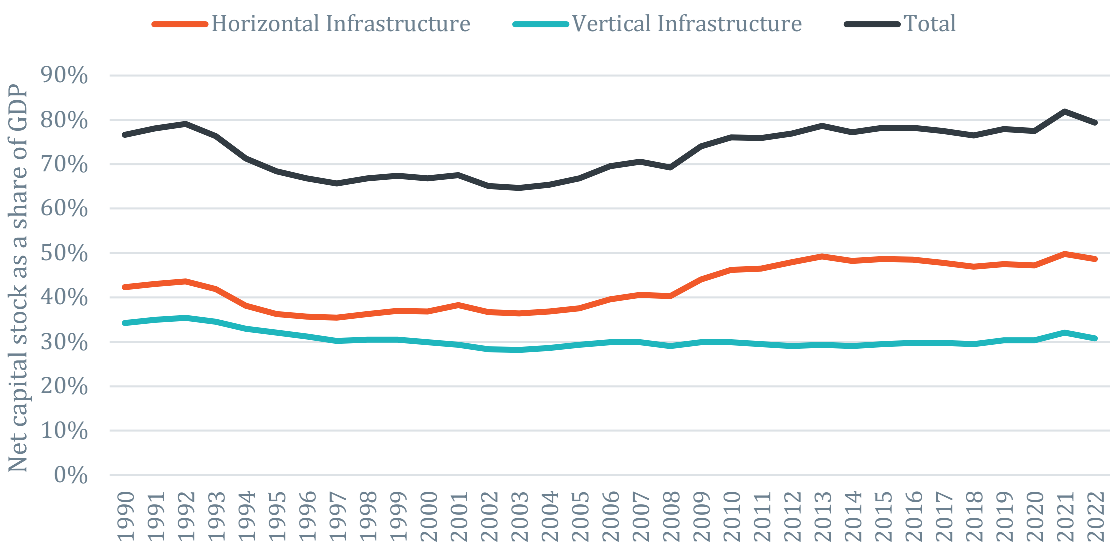
The value of infrastructure assets as a share of GDP

Figure 10 shows the value of New Zealand's infrastructure over time as a share of GDP. By looking at the values as a share of GDP we can see whether our investment in infrastructure is keeping pace with the rate at which the economy is growing.

Over the full 1990–2022 period, the value of our infrastructure has grown at approximately the same rate as the economy as a whole. New Zealand's infrastructure was valued at around 77% of GDP in 1990 and around 79% of GDP in 2022. Horizontal infrastructure has increased slightly, relative to the size of our economy, while vertical infrastructure has declined slightly.

Relative to GDP, the value of both horizontal and vertical infrastructure declined in the early 1990s. Since then, the value of horizontal infrastructure has risen, relative to GDP, while the value of vertical infrastructure has stabilised as a share of GDP. Over the last decade, the value of horizontal infrastructure has been stable at slightly less than 50% of GDP, while the value of vertical infrastructure has been stable at around 30% of GDP.

Figure 10: Value of New Zealand's infrastructure as a share of GDP, 1990–2022



The real value of infrastructure assets per capita

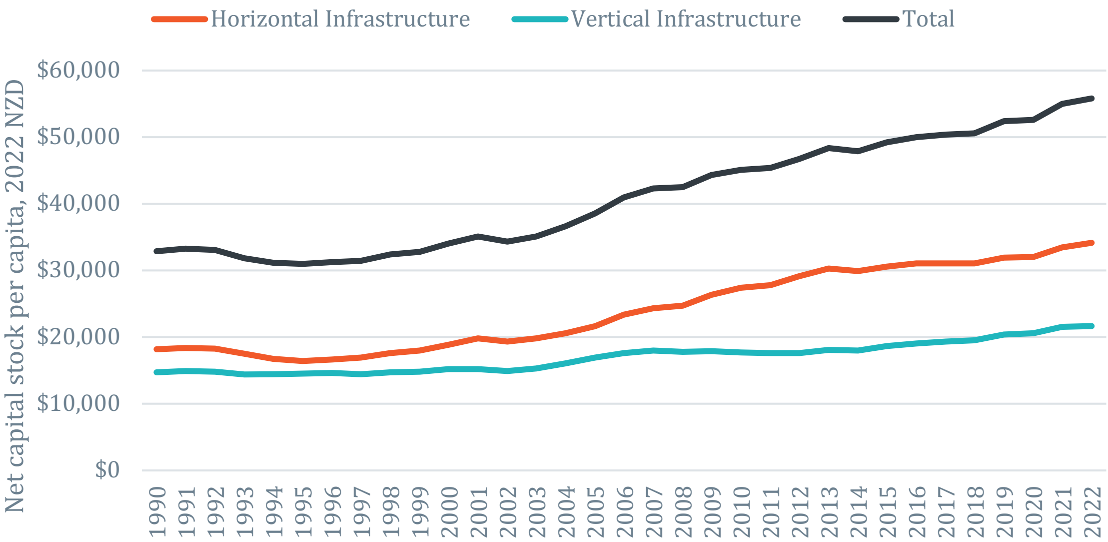
Figure 11 shows the per-capita value of New Zealand's infrastructure assets over time.

The per-capita value of infrastructure assets has generally risen over time. In 1990, we had an average of $32,900 of infrastructure assets per person. This consisted of $18,200 of horizontal infrastructure assets and $14,700 of vertical infrastructure assets per person.

In 2022, we had an average of $55,800 of infrastructure assets per person. This is a 70% increase in per-capita infrastructure assets. This consisted of $34,100 of horizontal infrastructure assets (an 88% increase) and $21,700 in vertical infrastructure assets (a 47% increase).

This suggests that the quantity and quality of infrastructure is rising significantly faster than New Zealand's population.

Figure 11: Real per-capita value of New Zealand's infrastructure assets, 1990–2022

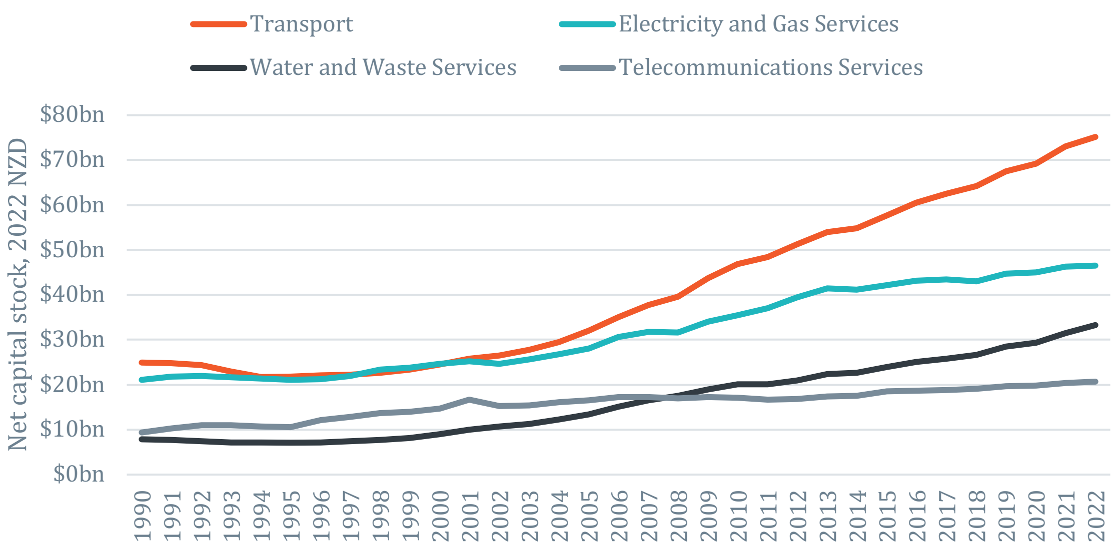


Horizontal infrastructure asset value in real terms

Figure 12 shows the value of New Zealand's horizontal infrastructure assets in real terms. In 1990, the total value of transport infrastructure was $25 billion, electricity and gas services infrastructure $20 billion, water and waste services infrastructure and telecommunications services infrastructure $10 billion each.

These total values were reasonably constant until the early 2000s when they began rising rapidly. Transport infrastructure saw a substantial increase, tripling to over $75 billion. Electricity and gas services also saw a significant increase, reaching over $46 billion in 2022. Water and waste services infrastructure more than tripled to $33 billion in 2022. Telecommunications services infrastructure saw the smallest relative increase, reaching $21 billion in 2022, just over double the 1990 value.

Figure 12: Value of New Zealand's horizontal infrastructure assets in 2022 dollars, 1990–2022

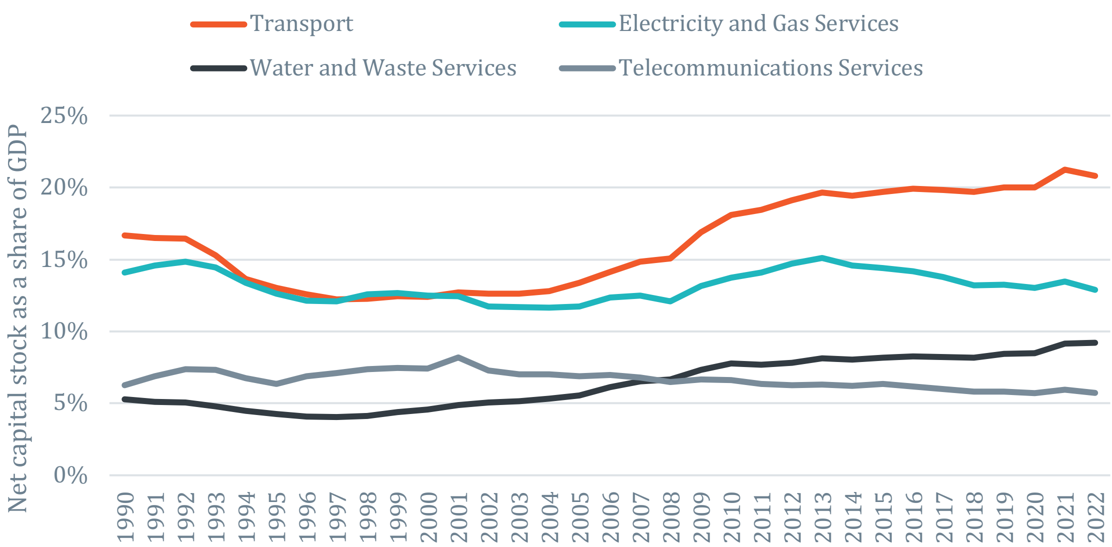


Horizontal infrastructure asset value as a share of GDP

Figure 13 shows the value of horizontal infrastructure assets as a share of GDP. Horizontal infrastructure assets have tended to grow at a similar or faster rate than New Zealand's economy, especially over the last 20 years.

The value of transport infrastructure increased from 12% of GDP at the turn of the century to 21% in 2022. Water and waste service infrastructure saw a similar increase, from around 5% of GDP at the turn of the century to 9% of GDP in 2022. The value of electricity and gas infrastructure and telecommunications infrastructure has remained a reasonably constant share of GDP over time, with some minor fluctuations.

Figure 13: Value of New Zealand's horizontal infrastructure assets as a share of GDP, 1990–2022

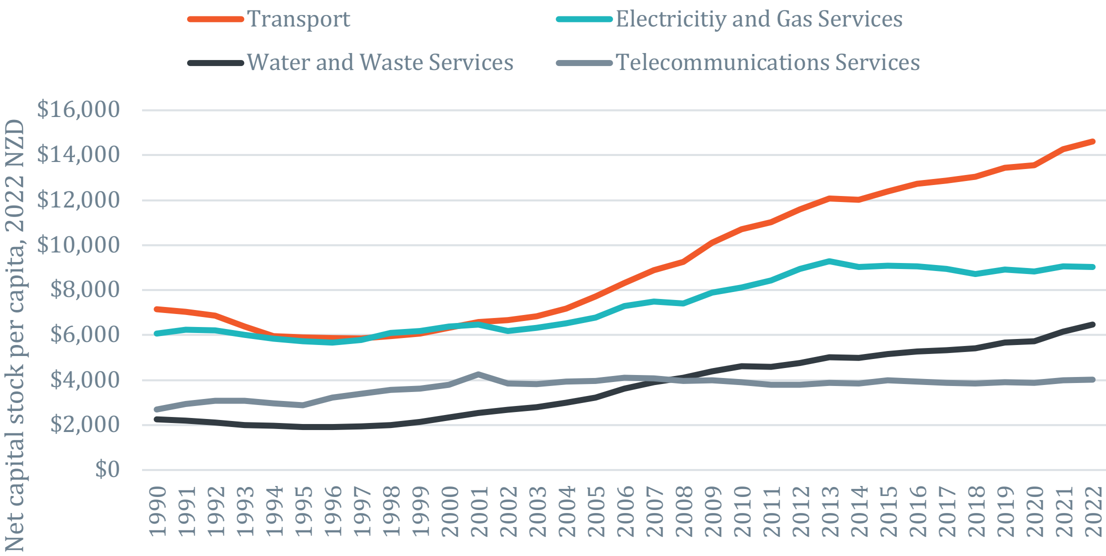


Horizontal infrastructure asset value per capita

Figure 14 shows the per-capita value of New Zealand's horizontal infrastructure assets over time. The value of these assets has grown at a faster rate than New Zealand's population.

The per-capita value of transport infrastructure increased from $7,160 in 1990 to $14,610 in 2022 (an 84% increase). The per-capita value of electricity and gas infrastructure rose from $6,060 in 1990 to $9,040 in 2022 (a 49% increase). The per-capita value of water and waste infrastructure rose from $2,620 in 1990 to $6,470 in 2022 (a 186% increase). Over the same period, the per-capita value of telecommunications infrastructure rose from $2,690 to $4,020 (a 49% increase).

Figure 14: Real per-capita value of New Zealand's horizontal infrastructure assets, 1990–2022



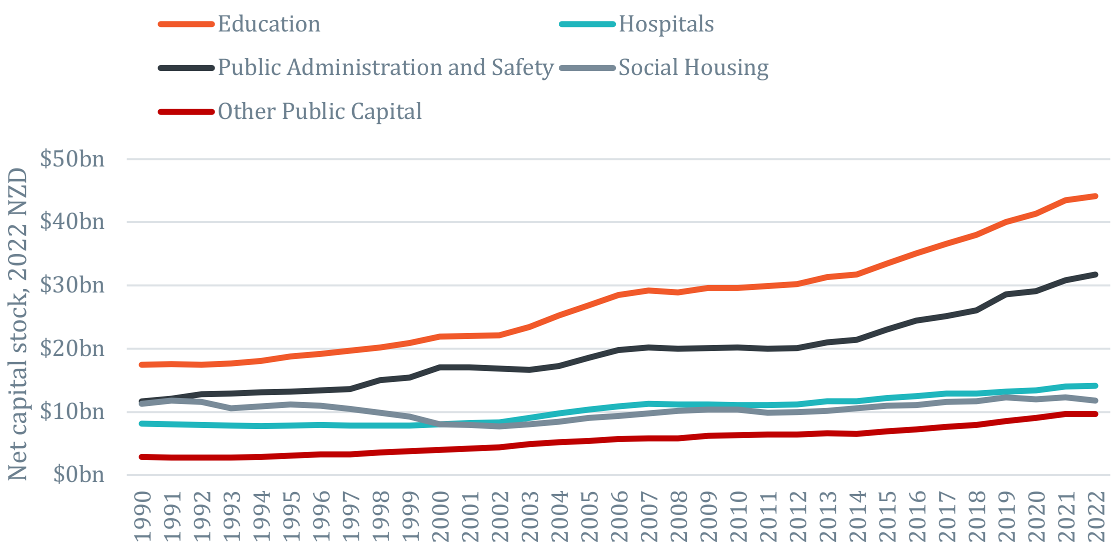
Vertical infrastructure asset value in real terms

Figure 15 looks at the value of vertical infrastructure assets in real terms. The 'other public capital' infrastructure category, which includes things like libraries, convention centres, and social assistance infrastructure, saw the largest percentage increase, from a low starting base. It increased $3 billion to $10 billion from 1990 to 2022.

Education infrastructure and public administration and safety infrastructure also both saw large increases. Education infrastructure increased 153% from 1990 to 2022, going from $17 billion to $44 billion. Public administration and safety infrastructure increased 172% from 1990 to 2022, going from $12 billion to $32 billion.

Hospital infrastructure saw a more modest increase in value, increasing from $8 billion in 1990 to $14 billion in 2022 (a 74% increase). The value of social housing has largely remained stagnant, being worth $11 billion in 1990 and $12 billion in 2022.

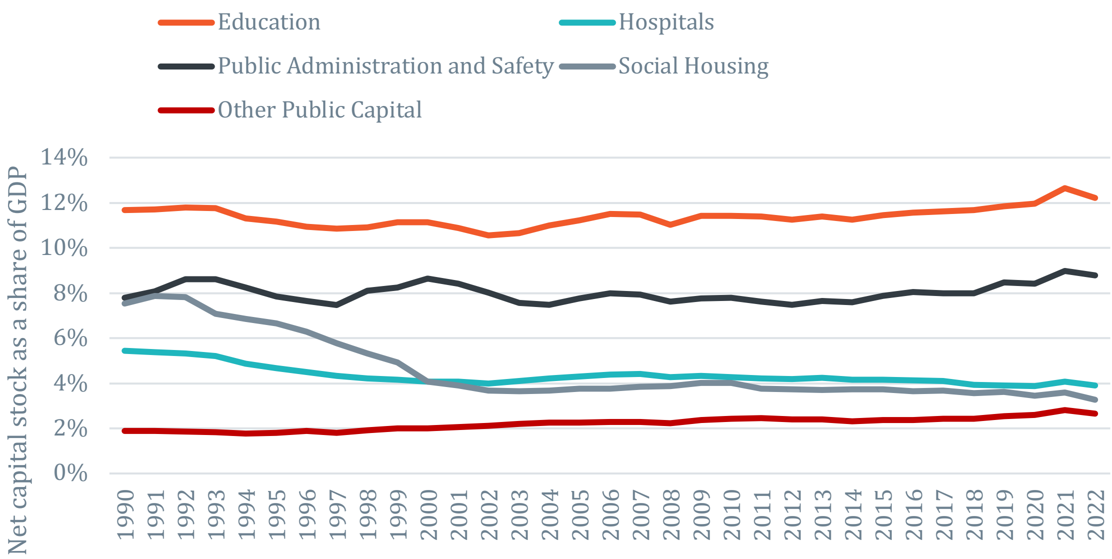
Figure 15: Value of New Zealand's vertical infrastructure assets in 2022 dollars, 1990–2022



Vertical infrastructure asset value as a share of GDP

The value of vertical infrastructure assets has mostly grown at a similar or slightly lower rate than New Zealand's economy. Education infrastructure has remained between 10% and 13% of GDP, public administration and safety infrastructure has remained around 8% of GDP, and other public capital infrastructure has remained around 2% of GDP.

Figure 16: Value of New Zealand's vertical infrastructure assets as a share of GDP, 1990–2022



The only two categories of vertical infrastructure to see notable change over time are hospitals and social housing. The value of New Zealand's hospitals has grown slower than the economy. Hospital infrastructure was worth 5.4% of GDP in 1990 declining to 3.9% in 2022.

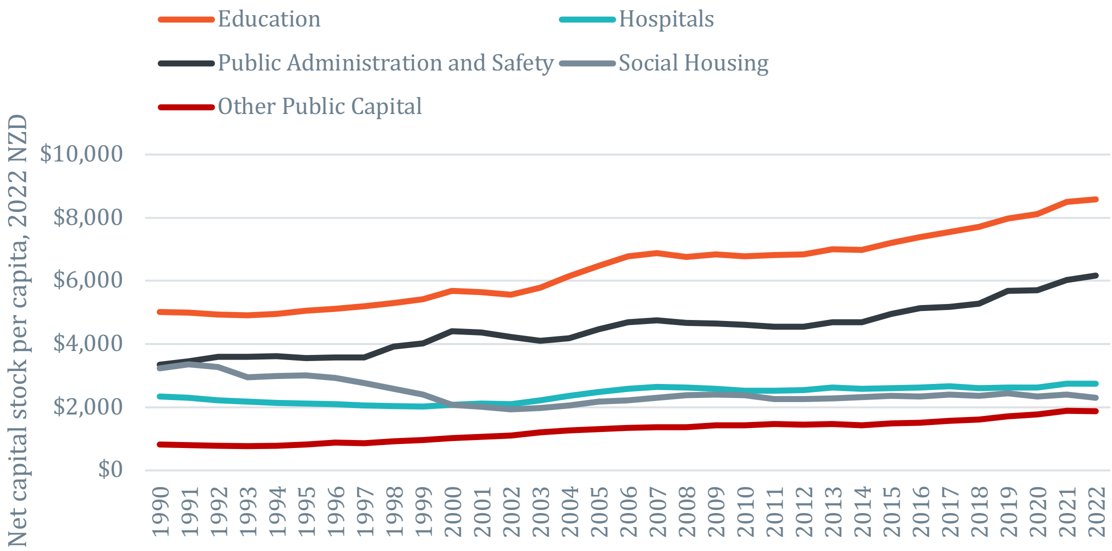
The value of social housing saw significant decline during the 1990s, falling from 7.9% of GDP in 1991 to 3.7% of GDP in 2002. Since 2002, the value of social housing infrastructure has remained at around 4% of GDP.

Vertical infrastructure asset value per capita

Figure 17 shows the per-capita value of New Zealand's vertical infrastructure assets over time. The value of some types of assets has grown at a faster rate than New Zealand's population, while the value of other assets has grown at a similar or slower rate.

The per-capita value of education infrastructure increased from $5,010 in 1990 to $8,580 in 2022 (a 71% increase). Over the same period, the per-capita value of public administration and safety infrastructure (including defence) increased from $3,350 to $6,170 (an 84% increase) and the per-capita value of other public capital, such as libraries, stadiums, and convention centres, increased from $810 to $1,870 (a 130% increase). By contrast, the per-capita value of hospitals increased more slowly, from $2,340 to $2,750 (a 17% increase), and the per-capita value of social housing declined from $3,230 to $2,300 (a 29% decrease).[10]

Figure 17: Real per-capita value of New Zealand's vertical infrastructure assets, 1990–2022



Contrasting results for education infrastructure and hospital infrastructure are striking in light of New Zealand's ageing population and declining family sizes. Education

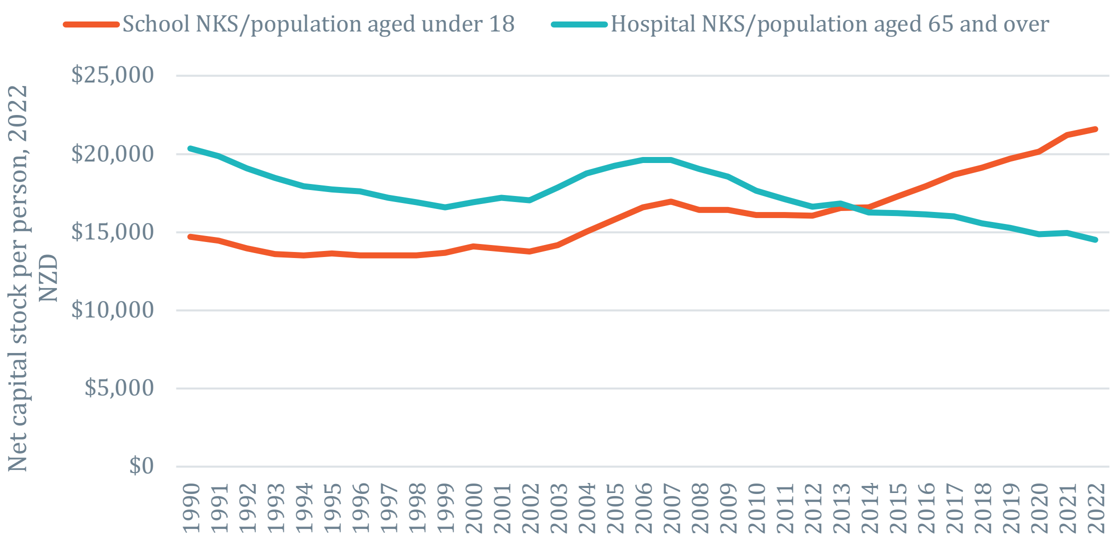
[10] Social housing predominantly serves people on low incomes who face challenges accessing market-rate housing. Determining whether value of social housing has increased or declined relative to the number of low-income people who may need these services is harder, as choosing a different a poverty line will affect the result. For instance, Perry (2019) shows that the share of people living under the poverty line has declined over time if measured against an inflation-adjusted 2007 poverty line, but risen over time if measured against an annually adjusted poverty line that captures relative deprivation. As a result, using the first measure will suggest that the value of social housing assets per low-income person has risen over time, while using the second measure will suggest that the value of social housing assets per low-income person has fallen over time.

infrastructure primarily serves younger people, while hospital infrastructure is most heavily used by older people.

Figure 18 therefore compares the real value of New Zealand's primary and secondary school education against the number of people aged under 18, and compares the real value of New Zealand's hospital infrastructure to the number of people aged 65 and over. The figures in this graph are higher than the ones reported in Figure 17 as we are comparing infrastructure asset values against a subset of the overall New Zealand population.

Over the last decade, the value of school infrastructure has risen more rapidly than the number of school-aged children, while the value of hospital infrastructure has risen more slowly than the population of retirement-aged people.

Figure 18: Real value of New Zealand's school and hospital infrastructure relative to population in the relevant age group, 1990–2022



New Zealand’s capital investment in infrastructure

In this section, we use Stats NZ’s gross fixed capital formation data to understand how much we are currently investing in new or improved infrastructure, and how our rate of investment has changed over time. We break the figures down by sector of ownership and by type of infrastructure.

Gross fixed capital formation measures how much is being added to the fixed capital stock. GFKF captures both additions to and disposal of capital stock, along with major improvements to tangible non-produced assets, such as land, and includes costs associated with the transfers of ownership of non-produced assets.

Current trends in capital investment in infrastructure

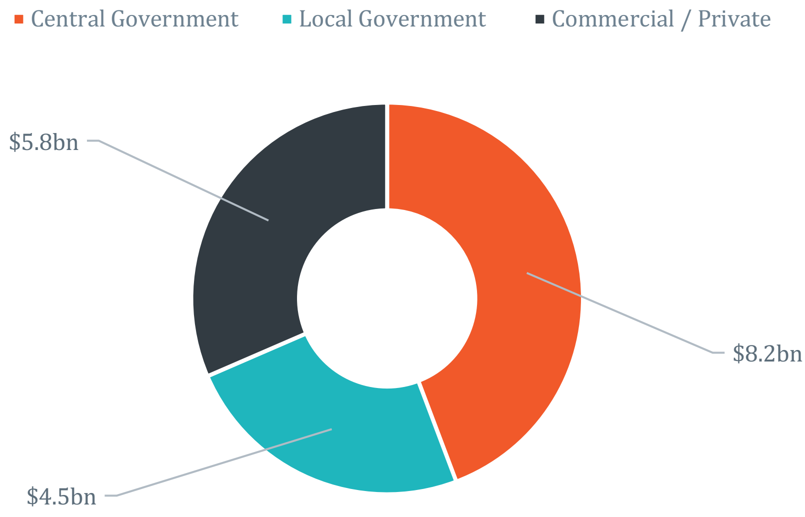
Summary by sector of ownership

Figure 19 shows average real gross fixed capital formation by sector of infrastructure ownership. Because the composition of investment changes slightly from year to year, we take the average annual inflation-adjusted investment for the 2013–2022 period.

During this time, central government accounted for the largest share of gross fixed capital formation in infrastructure, with an average annual investment of $7.1 billion (44% of the total). This is followed by GFKF in commercial/private-sector infrastructure at $5.3 billion per year (32% of the total) and local government GFKF at $3.8 billion per year (24% of the total).

Over this period, overall capital investment in infrastructure has averaged 5.8% of GDP.

Figure 19: Average annual real gross fixed capital formation in infrastructure by sector of ownership, 2013–2022



Summary by infrastructure network

Figure 20 presents a more detailed breakdown of the share of GDP invested in the different infrastructure sectors over the 2013–2022 period. This figure has an additional breakdown by sector of ownership.

Road transport is the largest investment category, equivalent to 1.1% of GDP.[11] This is approximately evenly split between central government and local government gross fixed capital formation.[12] Investment in other transport infrastructure is much lower at just over 0.2% of GDP.

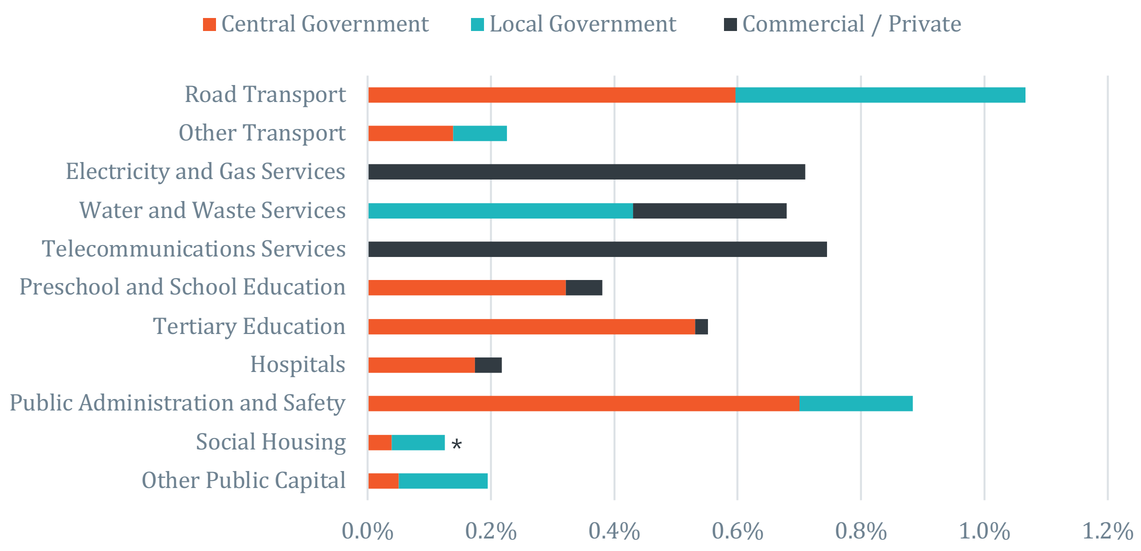
The other government-owned sectors seeing significant investment are public administration and safety (0.9% of GDP) and tertiary education (0.5% of GDP). Preschool and school education (0.3%), hospitals (0.2%), other public capital (0.2%), and social housing (0.15%) round out the rest of investment in publicly owned vertical infrastructure. Average annual local government investment in water and waste infrastructure is 0.4% of GDP.

[11] This is higher than a commonly cited figure published in the International Transport Forum's Transport Statistics database. ITF data suggests that investment in road infrastructure has equalled around 0.6% of GDP over the last decade. However, the ITF dataset counts road maintenance and renewal investment separately. When summed together, the ITF data on road investment plus road maintenance equals around 1.2% of GDP over this period. We note that differences in data definitions between countries mean that ITF data is not very useful for international comparisons of road investment. Some countries, like New Zealand, categorise renewal investment as maintenance spending, rather than investment, while others include renewal investment in their measure of investment.
See https://www.oecd-ilibrary.org/transport/data/itf-transport-statistics_trsprt-data-en

[12] Local government transport spending is partly funded through the National Land Transport Fund, so the central government share of funds is larger than their share of investment.

Commercial or private-sector investment in infrastructure is mainly directed towards electricity and gas infrastructure (averaging 0.8% of GDP) and telecommunications infrastructure (0.7% of GDP). There are also smaller investments in water and waste infrastructure (0.2% of GDP) and several types of vertical infrastructure (preschool and school education, tertiary education, and hospital infrastructure, adding up to around 0.1% of GDP).

Figure 20: Average annual real gross fixed capital formation as a share of GDP, by infrastructure sector, 2013–2022

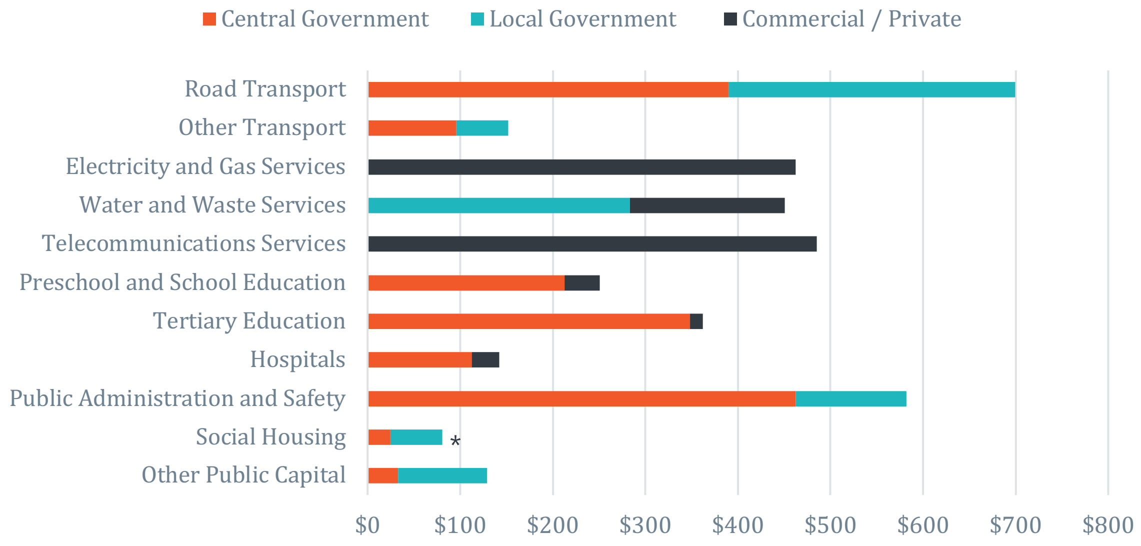


** Social housing GFKF data not available for the years 2020–2022*

Figure 21 shows average per-capita investment in the different infrastructure sectors over the 2013–2022 period, broken down by sector of ownership.

Over the 2013–2022 period, we invested an average of $3780 per capita, per year. Per-capita investment has generally grown over time, due to increases in per-capita GDP, meaning that in 2022 we invested an average of $4450 per capita in new and improved infrastructure.

Figure 21: Average annual real per-capita value of gross fixed capital formation, 2013–2022



** Social housing GFKF data not available for the years 2020–2022*

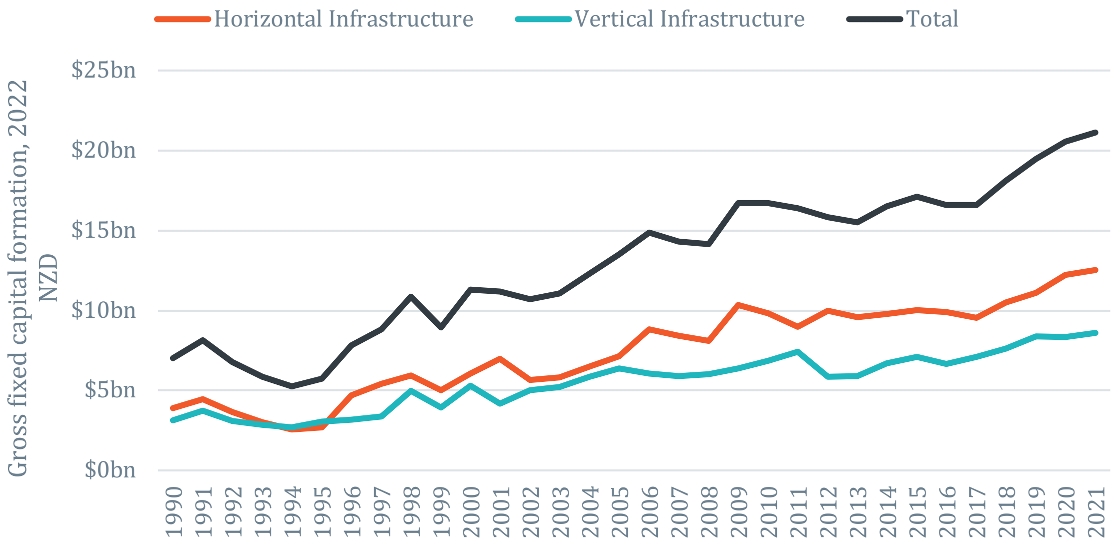
Capital investment in infrastructure over time

Infrastructure gross fixed capital formation in real terms

Figure 22 shows GFKF in horizontal and vertical infrastructure sectors in 2022 dollars. Total investment has risen for both categories over time, after a brief period of declining investment in the early 1990s.

In 1990, horizontal infrastructure GFKF was $3.9 billion, and vertical infrastructure GFKF was $3.1 billion. Over the last three decades, investment in horizontal infrastructure has grown faster than investment in vertical infrastructure, particularly since 2017. In 2022, horizontal infrastructure GFKF was $14.1 billion and vertical infrastructure GFKF was $8.8 billion.

Figure 22: Infrastructure gross fixed capital formation in 2022 dollars, 1990–2022



Infrastructure gross fixed capital formation as a share of GDP

Figure 23 shows gross fixed capital formation as a share of GDP for horizontal and vertical infrastructure for the 1990–2022 period.

The share of GDP invested in infrastructure declined in the early 1990s but rebounded in the late 1990s. Since then, the share of GDP invested in both horizontal and vertical infrastructure has been fairly consistent. Investment rates fluctuate slightly from year to year but have not trended upwards or downwards.

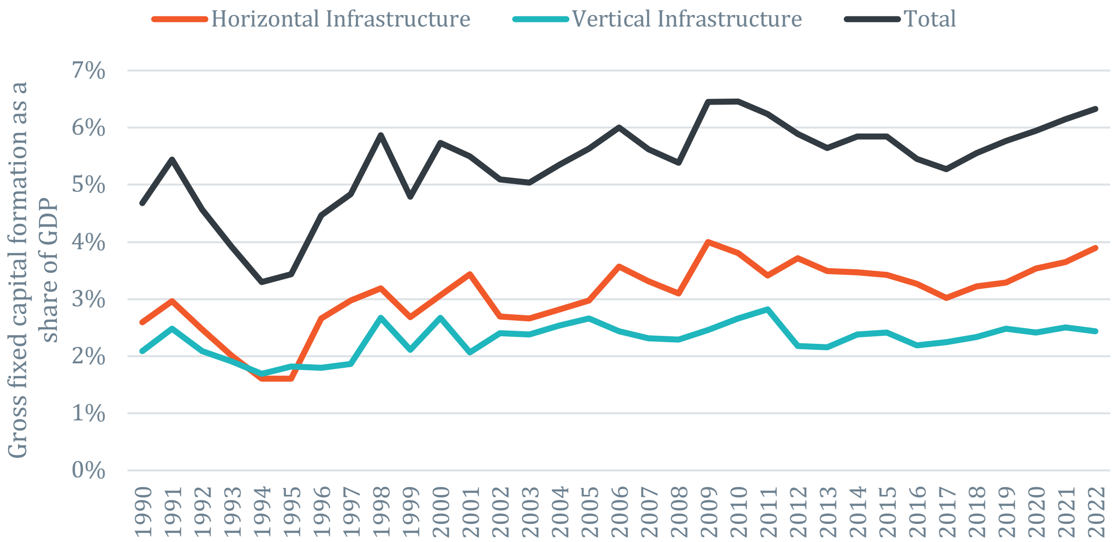
Between 2003 and 2022, total infrastructure GFKF ranged between 5.0% and 6.5% of GDP, with an average of 5.8%. Horizontal infrastructure investment ranged between 2.7% and 4.0% of GDP, with an average of 3.4%. Vertical infrastructure investment ranged between 2.2% and 2.8% of GDP, with an average of 2.4%.

Horizontal infrastructure investment has been slightly higher than average in the last few years. In 2022, we invested 3.9% of GDP in horizontal infrastructure and 2.4% of GDP in vertical infrastructure.

Fluctuating investment in the 1990s and consistently higher investment levels in the 2000s have influenced the changes in the value of infrastructure assets relative to GDP illustrated in Figure 10. The value of horizontal infrastructure is growing faster than the economy while the value of vertical infrastructure is growing at a similar rate, in part, because we are investing more in horizontal infrastructure.[13]

[13] As we discuss in the next section, depreciation rates also tend to be lower for horizontal infrastructure.

Figure 23: Infrastructure gross fixed capital formation as a share of GDP, 1990–2022

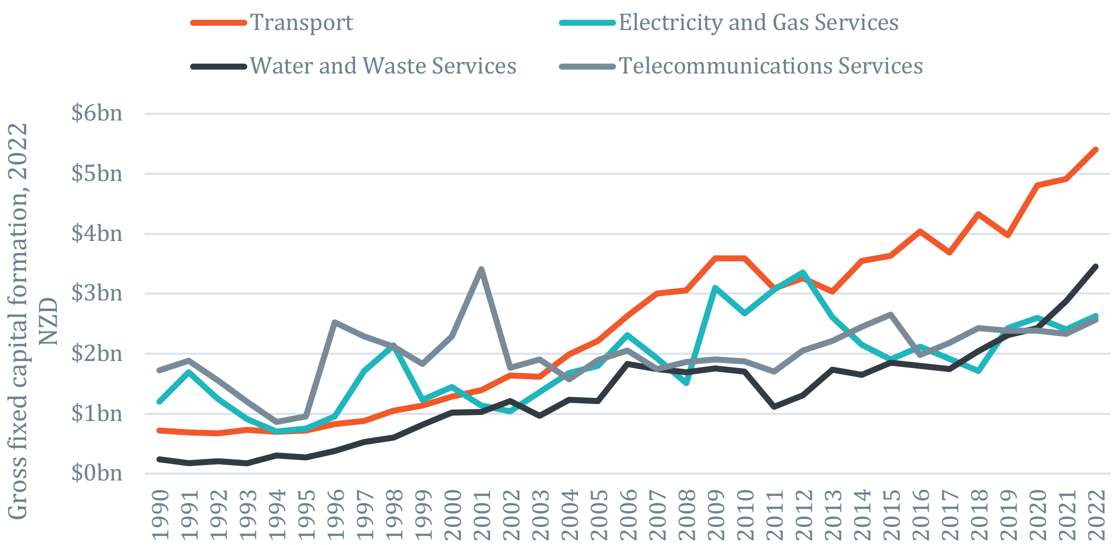


Horizontal infrastructure gross fixed capital formation in real terms

Figure 24 shows how significant investment in transport infrastructure has become. In 1990 GFKF in the transport sector was $0.7 billion in 2022 dollars. By 2022 this figure had grown to over $5.4 billion. The other sector to see a substantial increase in investment is water and waste services infrastructure. In 1990 net investment in water and waste services infrastructure was $0.2 billion and in 2022 it was $3.5 billion.

Gross fixed capital formation for electricity and gas services and telecommunications services infrastructure has also grown in real terms, but at a slower rate. In 1990, GFKF was $1.2 billion and $1.9 billion for electricity and gas services and telecommunications services infrastructure, respectively. In 2022 investment in both was $2.6 billion.

Figure 24: Horizontal infrastructure gross fixed capital formation in 2022 dollars, 1990–2022

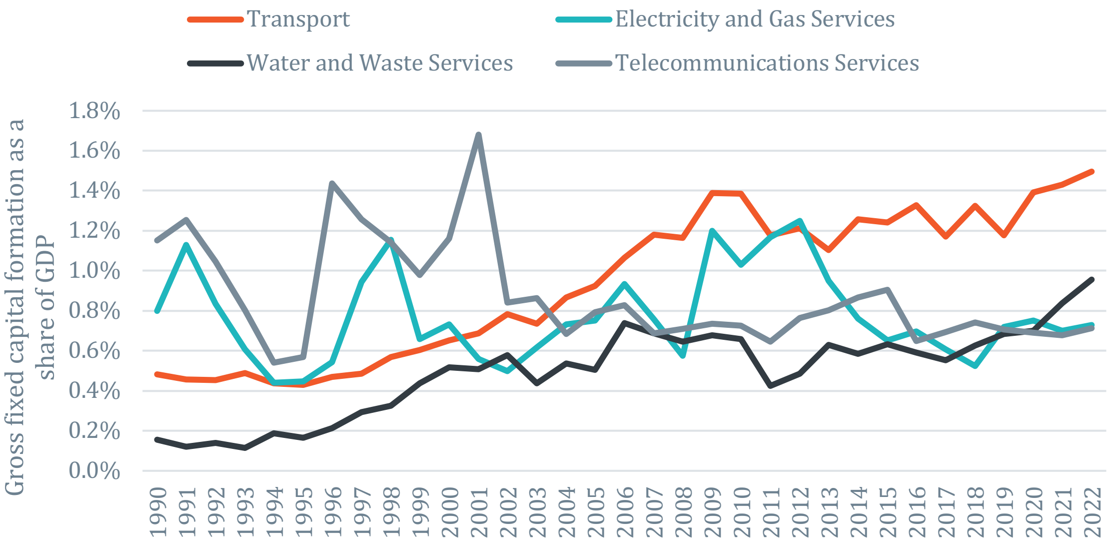


Horizontal infrastructure gross fixed capital formation as a share of GDP

Figure 25 shows the share of GDP invested in different horizontal infrastructure sectors. Investment in transport infrastructure tripled from 0.5% of GDP in 1990 to 1.5% of GDP in 2022. Investment in water and waste services infrastructure increased from 0.2% of GDP to nearly 1.0% of GDP over the same period. Part of this increase is due to a surge in investment since 2020.

The share of GDP invested in electricity and gas services and telecommunications services infrastructure gross fixed capital formation has fluctuated dramatically from year to year, but isn't trending upwards or downwards over time. Telecommunications services infrastructure GFKF peaked at 1.7% of GDP in 2001 before settling around 1.0% of GDP through to 2022. Electricity and gas services infrastructure GFKF has fluctuated between 0.4% and 1.3% of GDP over the 1990–2022 period.

Figure 25: Horizontal infrastructure gross fixed capital formation as a share of GDP, 1990–2022



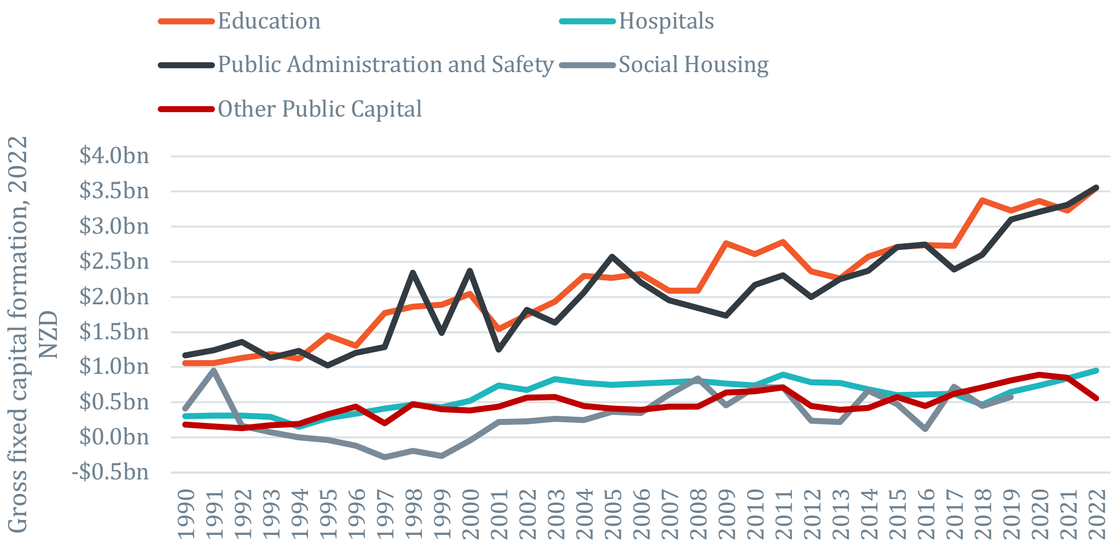
Vertical infrastructure gross fixed capital formation in real terms

Figure 26 shows how investment in vertical infrastructure sectors has changed over time, in inflation-adjusted 2022 dollars. Investment in education infrastructure and public administration and safety infrastructure has grown steadily over time. Education infrastructure GFKF was $1.1 billion in 1990, growing to $3.6 billion in 2022. Public administration and safety infrastructure GFKF was $1.2 billion in 1990 and $3.6 billion in 2022.

On the other hand, the dollar value of GFKF for hospital infrastructure and other public capital has not grown as much. Hospital infrastructure GFKF was $0.3 billion in 1990 and $1 billion in 2022. Other public capital GFKF was $0.2 billion in 1990 and $0.6 billion in 2022.

Gross fixed capital formation can be negative when more assets are being sold, disposed of, or consumed than is being acquired or constructed. This is the case for social housing between 1994 and 2000. GFKF for social housing was $0.4 billion in 1990 before turning negative in 1994 (reflecting net sales of social homes). After 2000 GFKF for social housing turns positive through to 2019 when our data ends, peaking at $0.8 billion in 2008 and being $0.6 billion in 2019.

Figure 26: Vertical infrastructure gross fixed capital formation in 2022 dollars, 1990–2022

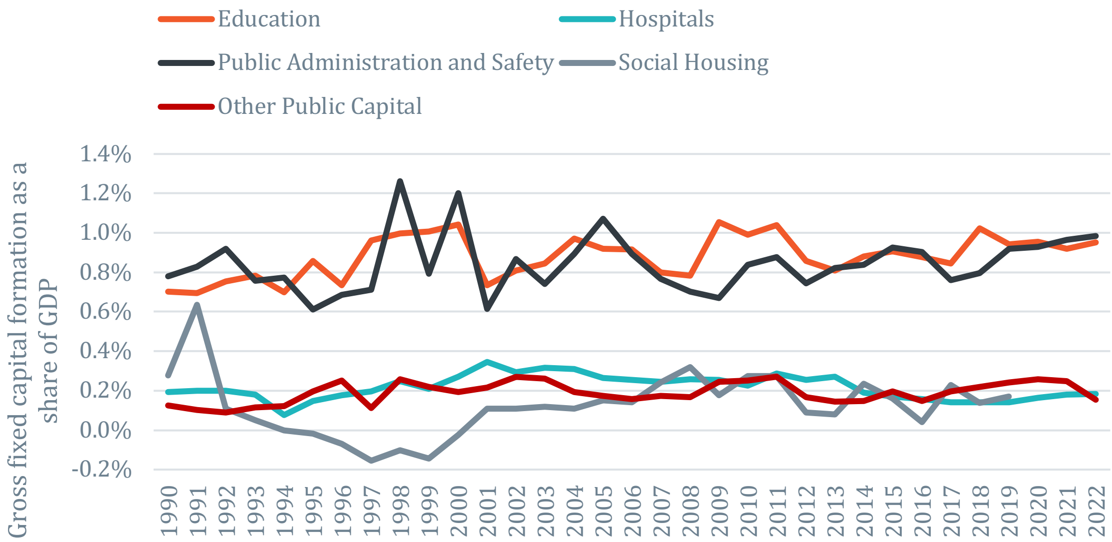


Vertical infrastructure gross fixed capital formation as a share of GDP

Figure 27 shows the share of GDP invested in different vertical infrastructure sectors. In contrast to horizontal infrastructure, investment in vertical infrastructure is relatively constant as a share of GDP. GFKF for education and public administration and safety infrastructure stays around 0.8% to 1.0% of GDP with only minor fluctuations. For hospitals and other public capital, gross fixed capital formation is consistently around 0.2% of GDP with minimal fluctuation.

As described above, GFKF for social housing infrastructure is different from the other categories in that it dips below zero for a period in the late 1990s, before turning positive again in 2001 and remaining around 0.1% of GDP through to 2019.

Figure 27: Vertical infrastructure gross fixed capital formation as a share of GDP, 1990–2022



Depreciation of infrastructure assets

In this section, we use Stats NZ's consumption of fixed capital data to understand how fast our infrastructure is depreciating, and how the cost of depreciation has changed over time. We break the figures down by sector of ownership and by type of infrastructure.

Consumption of fixed capital measures the annual decline in the value of fixed assets.[14] The decline in value can be due to physical wear and tear, obsolescence due to technological change, or normal accidental damage. CFK does not include declines in asset values due to extraordinary events such as natural disasters.[15] Appendix 1 explains how consumption of fixed capital is calculated in the National Accounts.

Consumption of fixed capital is a rough estimate of what we need to spend on renewing or replacing infrastructure to maintain current service levels. However, required renewal investment could be higher or lower in practice. If infrastructure design standards increase over time, it may not be possible to do 'like for like' replacement of existing infrastructure assets. This would mean that renewals will end up being more expensive.[16] On the other hand, if CFK is due to technological obsolescence, it may be possible to replace existing infrastructure with new technologies that are cheaper to build or operate.

Average depreciation rates by infrastructure network

Figure 28 shows Stats NZ's estimated average depreciation rates for different infrastructure sectors for the years 1990 to 2022. This shows how quickly the value of infrastructure assets are declining due to physical wear and tear, obsolescence, or normal accidental damage. Differences between the different sectors can be explained by different assumptions made by Stats NZ about the useful life of different types of infrastructure assets.

Average depreciation rates are lowest for transport infrastructure, electricity and gas infrastructure, water and waste infrastructure, and social housing infrastructure. They are highest for telecommunications infrastructure, reflecting the rapid rate of technological change in this area, and public administration and safety infrastructure assets, which include defence infrastructure and weapons systems. Average depreciation rates for education, hospitals, and other public capital are somewhere in the middle.

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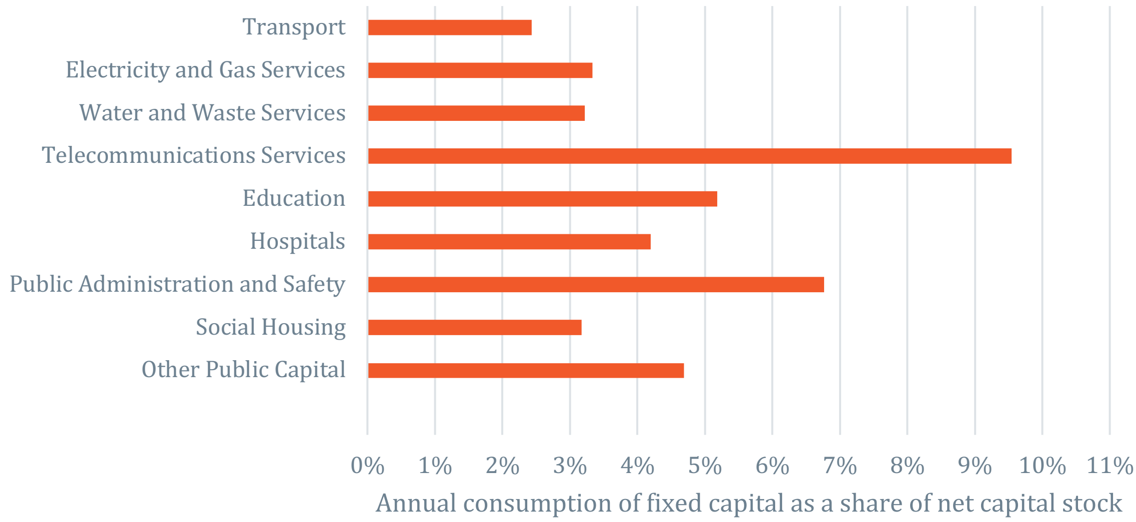
[14] In the System of National Accounts, CFK is treated as a cost of production for firms as it measures their use of long-lived assets.

[15] Losses due to extraordinary events are reflected in the NKS figures. The losses are recorded in a separate 'other changes in volume of assets' account, rather than in the CFK account.

[16] As an example, the Treasury estimates that the move from 'full replacement' insurance cover to 'sum insured' cover, where insurance payments are capped at an estimate of what it would currently cost to rebuild a similar home, has led to widespread underinsurance of residential homes (Sergeant, 2016).

Figure 28: Average depreciation rates for infrastructure sectors, 2013–2022



Note: Average depreciation rates are estimated by dividing annual consumption of fixed capital by net capital stock, and taking the average over a one-decade period. The 2013–2022 period was chosen for analysis as the value of New Zealand's infrastructure assets as a share of GDP was stable over this period (see Figure 10*).*

For transport infrastructure as a whole, annual consumption of fixed capital is only 2.4% of the net capital stock. This reflects asset life assumptions, with local government roading assets assumed to have an average asset life of 58 years and central government roading assets assumed to have an average asset life of 110 years (Statistics New Zealand, 2014). Railway construction assets are assumed to have an average life of 55 years.

Electricity and gas infrastructure and water and waste infrastructure have annual consumption of fixed capital equal to 3.3% and 3.2% of net capital stock, respectively. Power generation construction assets have an estimated average life of 60 years. The other assets in these categories likely fall into 'all other construction' and have an average life of 25-110 years depending on the specific asset.

Telecommunications services infrastructure assets have by far the highest ratio of annual CFK to NKS at 9.5%. Assets in this sector have a comparatively short lifespan due to rapid technological change. Electronic equipment machinery and electrical equipment machinery are estimated to have average asset lives of 8–12 and 16–33 years respectively. Some assets in this sector will also be in the 'all other construction' category with average lives of 25–110 years.

Education infrastructure and hospital infrastructure have average depreciation rates of 5.2% and 4.2%, respectively. Education infrastructure and hospital infrastructure assets both come under the 'non-residential buildings' category with assumed average assets lives of 45–65 years.

Public administration and safety infrastructure assets, which include defence infrastructure and weapons systems as well as courts, police stations, and prisons, have average depreciation rates of 6.8%. These assets include non-residential buildings with an average asset life of 45-65 years as well as equipment and machinery with a considerably shorter lifespan.

Social housing assets have annual consumption of fixed capital equal to 3.2% of net capital stock. This number is lower than that for education and hospital buildings, reflecting the assumption that residential buildings have longer average asset lives compared to non-residential buildings. Residential buildings are assumed to have an average life of 70 years.

The other public capital category includes telecommunications, internet, and library services infrastructure, social assistance infrastructure, and arts, recreation, and other service infrastructure. These assets have average depreciation rates of 4.9%, and often fall in the non-residential buildings category.

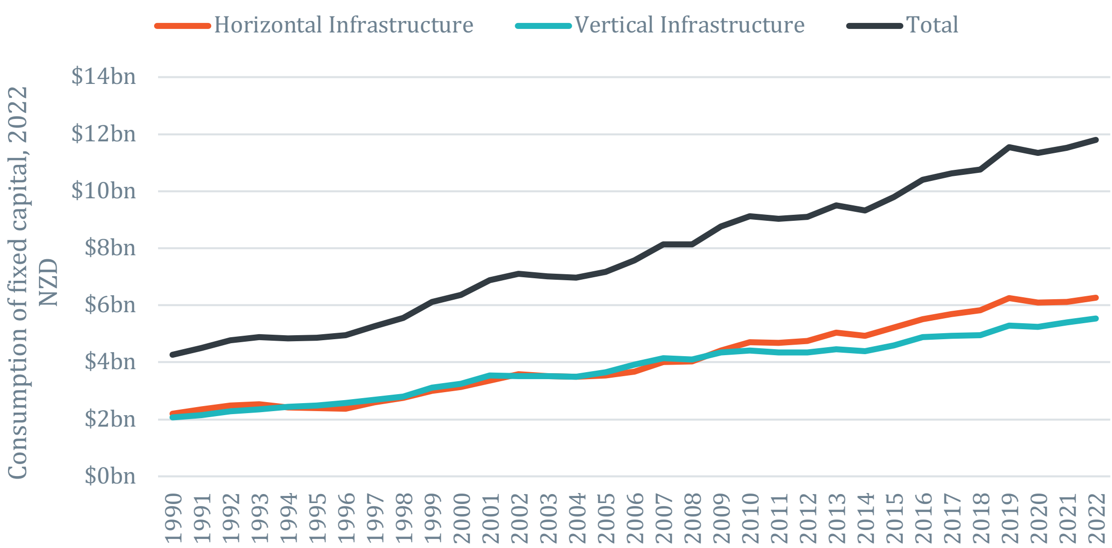
Depreciation costs for infrastructure over time

Infrastructure consumption of fixed capital in real terms

Figure 29 shows total infrastructure consumption of fixed capital in 2022 dollars. CFK for both horizontal and vertical infrastructure has steadily increased over time, reflecting the increase in the value of infrastructure over time that we saw in Figure 9. This highlights the fact that, as the total value of our infrastructure assets increases, the cost of depreciation and hence our eventual maintenance and renewal liabilities will also increase.

From 1990 to 2022, CFK for horizontal infrastructure rose from $2.2 billion to $6.3 billion. CFK for vertical infrastructure grew from $2.1 billion to $5.5 billion. The faster increase in depreciation costs for horizontal infrastructure reflects higher levels of investment in horizontal infrastructure over this period.

Figure 29: Infrastructure consumption of fixed capital in 2022 dollars, 1990–2022

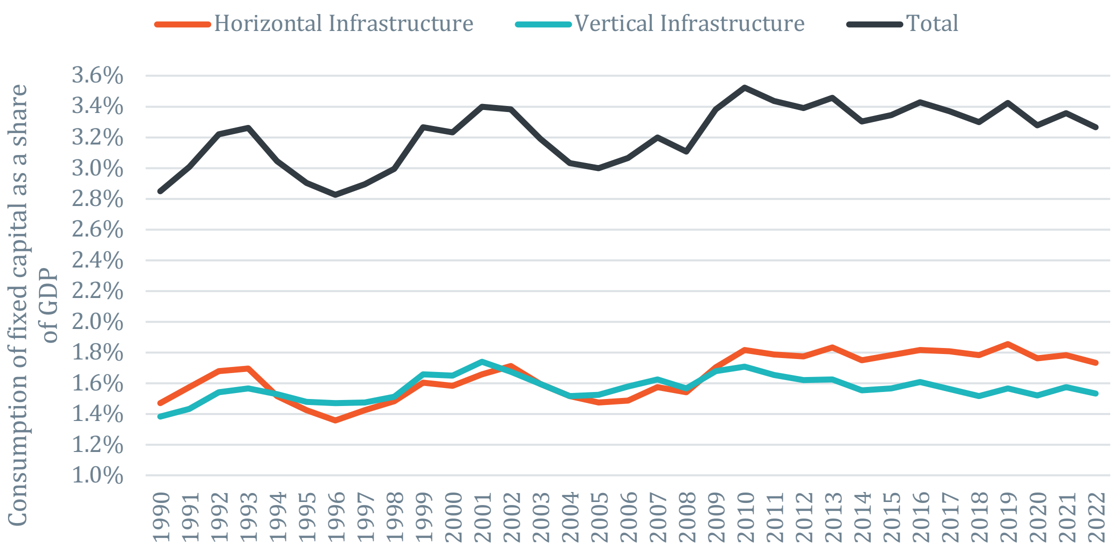


Consumption of fixed capital as a share of GDP

Figure 30 shows consumption of fixed capital as a share of GDP for horizontal and vertical infrastructure. CFK for vertical infrastructure is reasonably constant, remaining at around 1.5% of GDP. This reflects the trend we saw in Figure 10 where the total value of the vertical infrastructure stock is also relatively constant. Without any changes in the rate of physical wear and tear, the normal rate of obsolescence, or the normal rate of accidental damage, we would expect CFK to track with net capital stock value.

As a share of GDP, CFK of horizontal infrastructure has risen slightly over time. Since 2010, it has averaged around 1.8% of GDP. This reflects increases in the value of horizontal infrastructure assets, relative to GDP, over time.

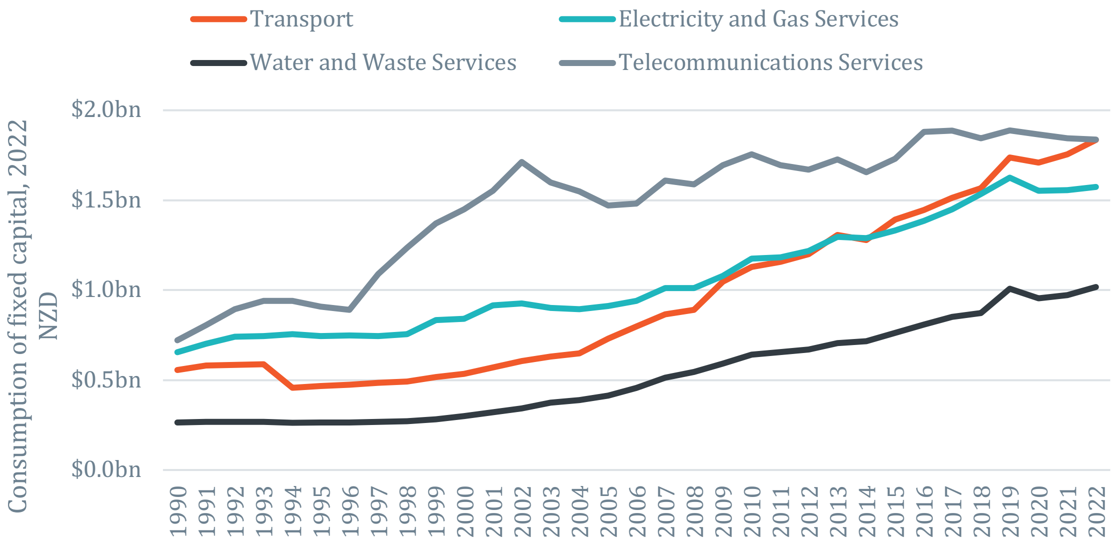
Figure 30: Infrastructure consumption of fixed capital as a share of GDP, 1990–2022



Consumption of fixed capital in real terms for horizontal infrastructure

Figure 31 shows consumption of fixed capital in real terms for the horizontal infrastructure sectors. CFK for all sectors increases over time. The two notable sectors are transport, where there have been ongoing increases in CFK due to higher investment levels, and telecommunications infrastructure, where CFK rose rapidly in the late 1990s as the industry entered a period of rapid technological change, including deployment of mobile phones and the growth of the internet.

Figure 31: Horizontal infrastructure consumption of fixed capital in 2022 dollars, 1990–2022

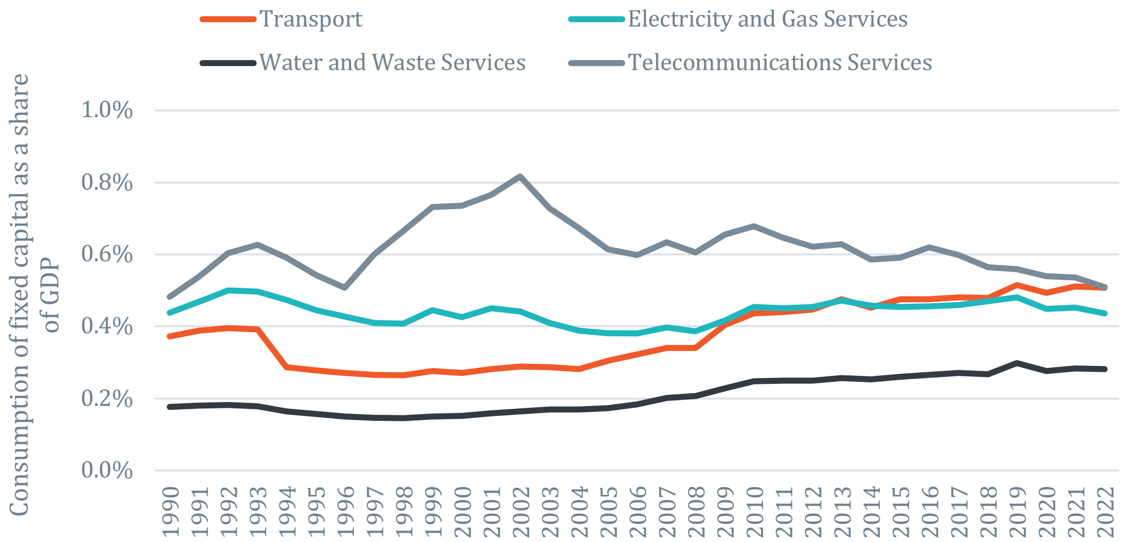


Consumption of fixed capital as a share of GDP for horizontal infrastructure

Figure 32 shows consumption of fixed capital as a share of GDP for horizontal infrastructure sectors. CFK is reasonably constant for electricity and gas services infrastructure at around 0.4% to 0.5% of GDP. Similarly, water and waste services infrastructure CFK is reasonably constant, with a slight upwards trend from 0.2% to 0.3% of GDP over the sample period.

Transport infrastructure CFK sees an upward trend from the early 2000s, reaching 0.5% of GDP in 2022. This follows the large increase in the net capital stock of transport infrastructure over this period. Telecommunications services infrastructure is the most volatile, with annual CFK ranging from 0.5% of GDP in 1996, to 0.8% in 2002, before settling around 0.6% through to 2022.

Figure 32: Horizontal infrastructure consumption of fixed capital as a share of GDP, 1990–2022

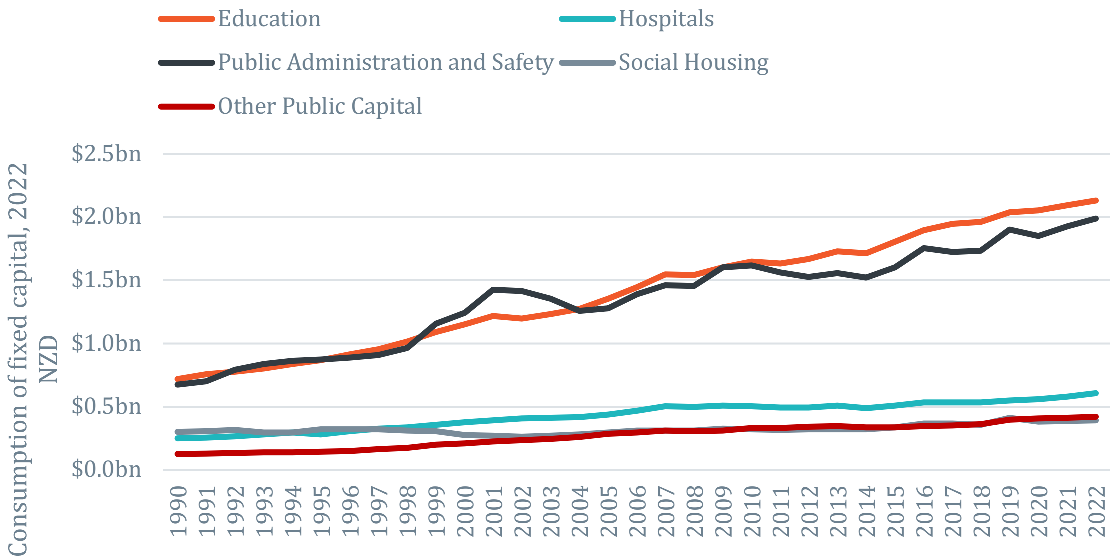


Consumption of fixed capital in real terms for vertical infrastructure

Figure 33 shows consumption of fixed capital in real terms for vertical infrastructure sectors. CFK for education infrastructure and public administration and safety infrastructure are very similar and both steadily increase over time. CFK for both was $0.7 billion in 1990, rising to $2.1 billion and $2.0 billion, respectively, in 2022.

CFK for hospital infrastructure, social housing, and other public capital infrastructure is more constant over time. CFK for each of these sectors is around $0.1 to $0.3 billion in 1990 and $0.4 to $0.6 billion in 2022. The growth in education and public administration and safety infrastructure CFK and the lack of growth in hospital, social housing, and other public capital infrastructure CFK again reflects growth and lack of growth in the value of those infrastructure networks.

Figure 33: Vertical infrastructure consumption of fixed capital in 2022 dollars, 1990–2022

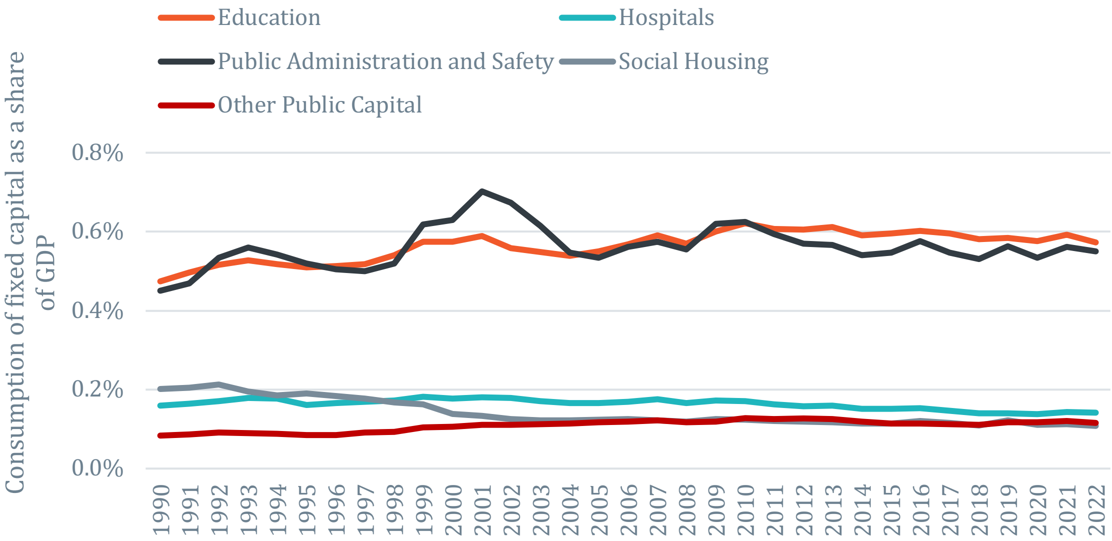


Consumption of fixed capital as a share of GDP for vertical infrastructure

Figure 34 shows consumption of fixed capital as a share of GDP for vertical infrastructure sectors. CFK is more constant for vertical infrastructure than it is for horizontal infrastructure, because the net capital stock value of vertical infrastructure grew in line with GDP from 1990 to 2022.

CFK for hospitals, social housing, and other public capital infrastructure is consistently in the 0.1% to 0.2% of GDP range for the entire period. Education infrastructure and public administration and safety infrastructure see slightly more variation but are generally in the 0.5% to 0.6% of GDP range.

Figure 34: Vertical infrastructure consumption of fixed capital as a share of GDP, 1990–2022



The sufficiency of renewal investment

Infrastructure decision-makers have a choice between investing in new or improved assets and investing in maintaining and renewing existing assets. In the previous sections, we observed that New Zealand's capital investment in infrastructure has risen over time (Figure 22) but that the cost of depreciation for infrastructure has also risen (Figure 29). This raises the question of whether decision-makers are funding renewal in a way that will ensure sustainable asset performance over time.

In this section, we consider whether renewal investment, which is a subset of overall capital investment, is sufficient to cover depreciation and consumption of our infrastructure assets. We start by using Stats NZ's National Accounts data to compare the relative magnitude of gross fixed capital formation and consumption of fixed capital. This provides a rough estimate of how much of our current infrastructure investment needs to be directed towards renewal of existing infrastructure to ensure that asset condition is maintained in the long term.

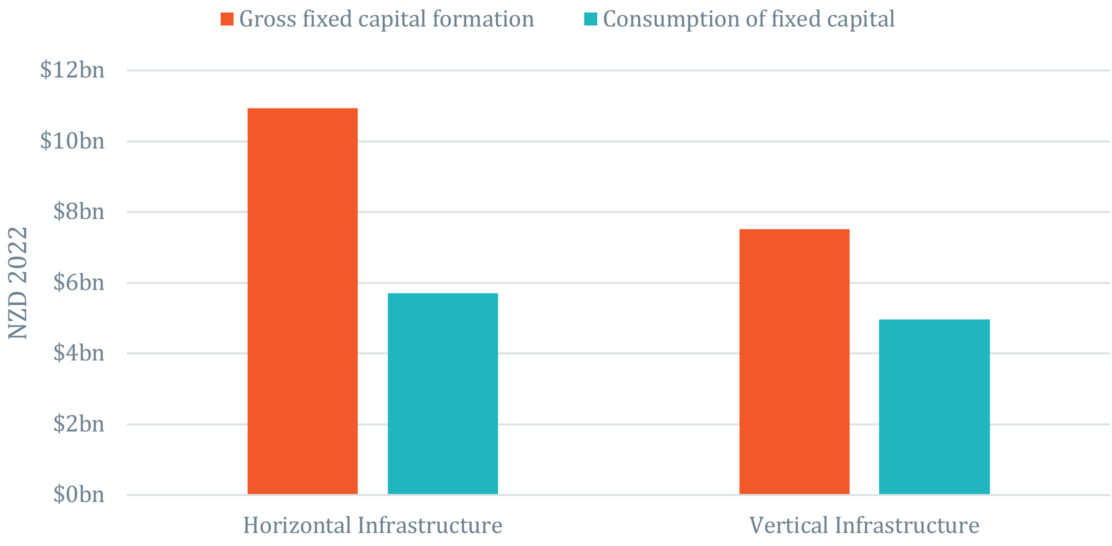
However, infrastructure providers may not be spending as much as they need to. We therefore analyse how actual or forecast renewal spending compares with depreciation for selected infrastructure sectors that publicly disclose this information. Finally, we use asset data for state highways and local roads to demonstrate how renewal spending translates through to actual renewal work and hence to asset condition outcomes.

The relative size of capital investment and depreciation

We begin by comparing the magnitude of gross fixed capital formation to consumption of fixed capital. This analysis provides a broad, high-level perspective on the proportion of overall capital investment that would need to be spent on renewals to maintain asset condition over time. However, it does not allow us to identify whether that money is *actually* being spent.

Figure 35 below shows average annual gross fixed capital formation and consumption of fixed capital for horizontal and vertical infrastructure. The figures are annual averages for 2013–2022, in real 2022 dollars.

Figure 35: Average annual real GFKF and CFK for infrastructure, 2013–2022



Average GFKF for horizontal infrastructure has been $10.8 billion a year and average CFK has been $5.6 billion a year. Average GFKF for vertical infrastructure has been $7.4 billion a year and average CFK has been $4.9 billion a year. This suggests that, to maintain the condition of these assets, it would be necessary to spend around 52% of current horizontal infrastructure capital investment on renewal and replacement, and around 67% for vertical infrastructure.

The lower ratio for horizontal infrastructure reflects the fact that these assets tend to be longer-lived and require less frequent renewals than vertical infrastructure assets (as reflected in average depreciation rates reported in Figure 28).

However, these ratios vary between different infrastructure sectors. Table 3 breaks out the GFKF and CFK comparison for all infrastructure sectors that we analyse and calculates the ratio of CFK to GFKF for each sector.

The sectors with the lowest ratio of CFK to GFKF are central government road transport (state highways), with a ratio of 27%, and local government water and waste services, with a ratio of 33%. In these sectors, spending around one-third of overall capital investment on renewals may be sufficient to sustain asset conditions in the long run.

Aside from a few outliers, the sectors with the highest ratio of CFK to GFKF are central government hospitals, with a ratio of 82%, telecommunications infrastructure, with a ratio of 77%, and central government tertiary education, with a ratio of 72%. In the case of hospitals and tertiary education, it may be necessary to spend around three-quarters of our current capital investment on renewals to sustain asset condition. Telecommunications infrastructure is a slightly different case, as faster rates of technological change result in a need to replace existing equipment with new equipment, rather than replacing existing equipment on a like-for-like basis.

We also find that the average ratio of CFK to GFKF varies between different sectors of ownership. Local government enjoys the lowest average ratio (44%), while central government (59%) and commercial/private infrastructure (67%) have substantially higher ratios. The higher ratio for central government reflects the fact that local government's infrastructure assets are mostly things like roads and pipes, which wear out relatively slowly, while central government's infrastructure assets include a greater mix of 'vertical' infrastructure assets like schools and hospitals that wear out relatively quickly.

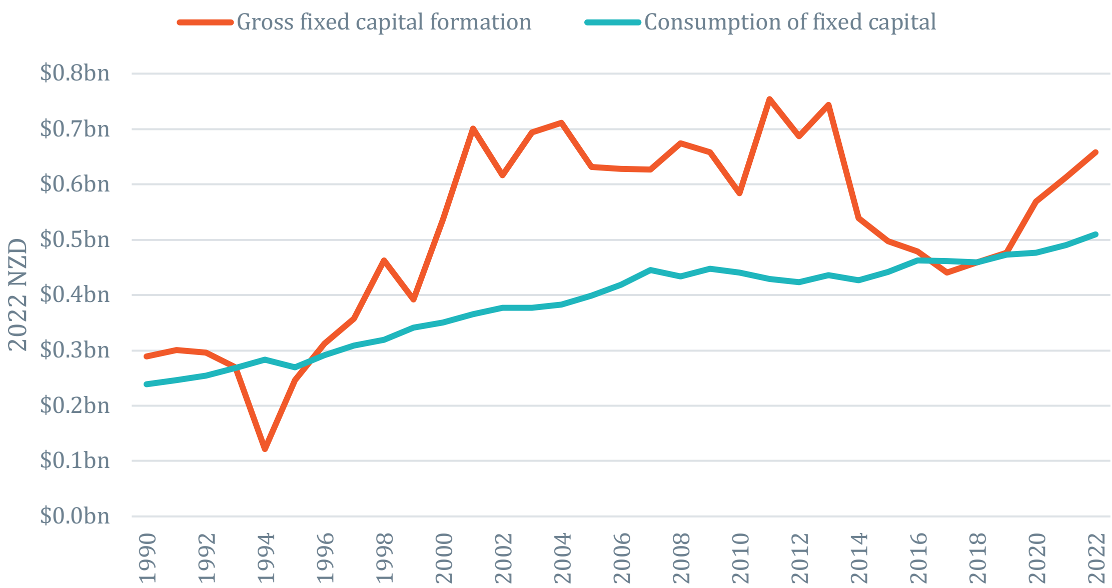
This means that, to maintain asset condition over time, central government and commercial/private infrastructure providers would need to devote a larger share of their current capital investment to renewal than local government.

Table 3: Average annual real gross fixed capital formation (GFKF) and consumption of fixed capital (CFK) by infrastructure sector, 2013–2022

Category	Infrastructure sector	Ownership sector	GFKF	CFK	CFK/GFKF
Horizontal	Road Transport	Central Government	$1,893m	$525m	28%
		Local Government	$1,507m	$676m	45%
	Other Transport	Central Government	$467m	$201m	43%
		Local Government	$270m	$152m	56%
	Electricity and Gas Services	Commercial/Private	$2,247m	$1,460m	65%
	Water and Waste Services	Local Government	$1,376m	$445m	32%
		Commercial/Private	$812m	$422m	52%
	Telecommunications Services	Commercial/Private	$2,356m	$1,816m	77%
Vertical	Preschool and School Education	Central Government	$1,033m	$574m	55%
		Commercial/Private	$183m	$94m	51%
	Tertiary Education	Central Government	$1,666m	$1,196m	72%
		Commercial/Private	$67m	$59m	88%
	Hospitals	Central Government	$548m	$464m	85%
		Commercial/Private	$145m	$76m	52%
	Public Administration and Safety	Central Government	$2,248m	$1,404m	62%
		Local Government	$578m	$351m	61%
	Social Housing	Central Government	$121m	$278m	230%
		Local Government	$270m	$85m	32%
	Other Public Capital	Central Government	$159m	$157m	99%
		Local Government	$470m	$214m	46%
Total horizontal infrastructure			**$10,928m**	**$5,696m**	**52%**
Total vertical infrastructure			**$7,120m**	**$4,736m**	**67%**
Total central government infrastructure			**$8,162m**	**$4,811m**	**59%**
Total local government infrastructure			**$4,471m**	**$1,924m**	**43%**
Total commercial/private infrastructure			**$5,415m**	**$3,698m**	**68%**
Total all infrastructure			**$18,048m**	**$10,432m**	**58%**

National Accounts data does not allow us to determine how much investment there has actually been in renewal in each of these networks. However, in some cases, the data strongly suggests that historical investment was unlikely to be sufficient to keep up with depreciation. For instance, Figure 36 shows that overall capital investment in central government hospitals fell below estimated depreciation in the mid-1990s and in the mid-2010s. During these periods, spending would have been insufficient to cover depreciation needs even if all capital investment in hospitals had been directed towards renewals.

Figure 36: Real capital investment and depreciation for central government hospitals, 1990–2022



Actual renewal investment relative to depreciation

We now take a closer look at how actual or forecast capital investment in asset renewal compares with depreciation for selected infrastructure sectors that disclose this information. We were able to gather relevant data for three types of horizontal infrastructure:

- road transport: state highways (central government); local roads (local government)
- electricity and gas services: electricity distribution; gas distribution (commercial)
- water and waste services: water supply; sewage treatment and disposal; stormwater drainage; flood protection and control works (local government).

These sectors account for around 38% of total capital investment in infrastructure. Data on actual state highway depreciation costs and renewal spending for the 2012–2022 period is sourced from NZ Transport Agency Waka Kotahi's (NZTA's) open data.[17] Data on

[17] NZTA publishes funding data groups together maintenance activities (100-series work activity classes) and renewal activities (200-series work activity classes) for specific assets. For instance, reported maintenance and renewal spending for pavement and seal includes six work activity classes (111, 121, 211, 212, 214, 231). This data is available for the 2011/12 to 2021/22 financial years. NZTA also publishes unaudited asset sustainability ratios that compare renewal expenditure (200-series work activity classes only) to depreciation for state highways. We used these asset sustainability ratios, plus data on depreciation for specific assets from NZTA's annual reports, to estimate total renewal spending on each asset class for the 2017/18 through 2021/22 financial years. A comparison between estimated renewal spending for state highways (estimated from asset sustainability ratios) and reported maintenance plus renewal spending (reported in NZTA's funding data) suggests that, over time, renewals account for around 42% of the overall maintenance plus renewal spending on state highways. We applied this ratio to convert published maintenance and renewal spending for state highways (corridor, environment & drainage, pavement & seal, structures) to estimated renewal spending. We then report a range for the renewal-to-depreciation ratio, with the lower end of the range based on estimated renewal spending alone and the upper end based on renewal plus maintenance spending. For source data see:
https://www.nzta.govt.nz/planning-and-investment/learning-and-resources/transport-data/data-and-tools/
https://www.nzta.govt.nz/planning-and-investment/planning-and-investment-knowledge-base/202124-nltp/2021-24-nltp-activity-classes-and-work-categories/local-road-and-state-highway-maintenance/
https://www.nzta.govt.nz/assets/resources/annual-report-nzta/2022-23/waka-kotahi-annual-report-2022-23-

forecast depreciation costs and renewal expenditure for local government infrastructure comes from local authorities' 2019–2028 long-term plans (LTPs), which are collated into a single data set by the Department of Internal Affairs and the local authority financial statistics collated by Stats NZ.[18] Data on actual electricity distribution and gas distribution depreciation costs and renewal expenditure is sourced from summaries of regulated utility information disclosures published by the Commerce Commission.[19]

These data sources are broadly comparable as they follow generally accepted accounting principles. However, they may use slightly different concepts for what types of expenditures are considered asset renewal expenditures. We have attempted to focus on renewal expenditures, which are expected to extend an asset's usable life (thereby offsetting depreciation), rather than maintenance expenditures, which typically include things such as repainting existing assets and trimming vegetation, or emergency reinstatement after natural disasters.[20]

Figure 37 shows the ratio of renewal expenditures to depreciation costs in each of these sectors. If this ratio remains below one for a long period of time, it suggests that assets may be wearing out faster than they are being renewed, as depreciation expenses exceed asset renewal expenditures. However, more detailed analysis of renewal activity and asset condition is needed to assess whether spending levels are causing problems.
There are two infrastructure sectors with renewal-to-depreciation ratios that are close to or above one:

- Flood protection and control works (local government): Forecast 2019–2028 renewal expenditure was expected to be more than twice as high as forecast depreciation. This appears to reflect a period of 'catch-up' investment, as renewal expenditures were substantially increased in the 2015 LTP round. However, flood protection investment remains a small share of councils' capital budgets.
- Electricity distribution (commercial): Between 2014 and 2021, electricity distributors' renewal spending was around 7% lower than depreciation costs.

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section-e-appendices.pdf
https://www.nzta.govt.nz/assets/resources/annual-report-nzta/2022-23/waka-kotahi-annual-report-2022-23-section-d-finances.pdf

[18] https://www.localcouncils.govt.nz/lgip.nsf/wpg_URL/Resources-Download-Data-Local-authority-long-term-plans
DIA has not yet published consolidated data for more recent long-term plans. However, the patterns we document here are consistent across the 2012, 2015, and 2018 LTP cycles. We note that 2021 LTPs may not be comparable as councils were preparing plans under the assumption that new water service entities would take over their three waters assets. As local government statistics are projections rather than actuals, they are not necessarily perfectly comparable to data for other sectors. 2012 and 2015 LTP projections of depreciation costs track closely with actual depreciation costs from local authority financial statistics. However, we can't see whether actual renewal expenditure tracked with projected renewal spending.

[19] For electricity distributors: https://comcom.govt.nz/regulated-industries/electricity-lines/electricity-distributor-performance-and-data/performance-summaries-for-electricity-distributors and for gas distribution: https://comcom.govt.nz/regulated-industries/gas-pipelines/gas-pipelines-performance-and-data/performance-summaries-for-gas-distributors

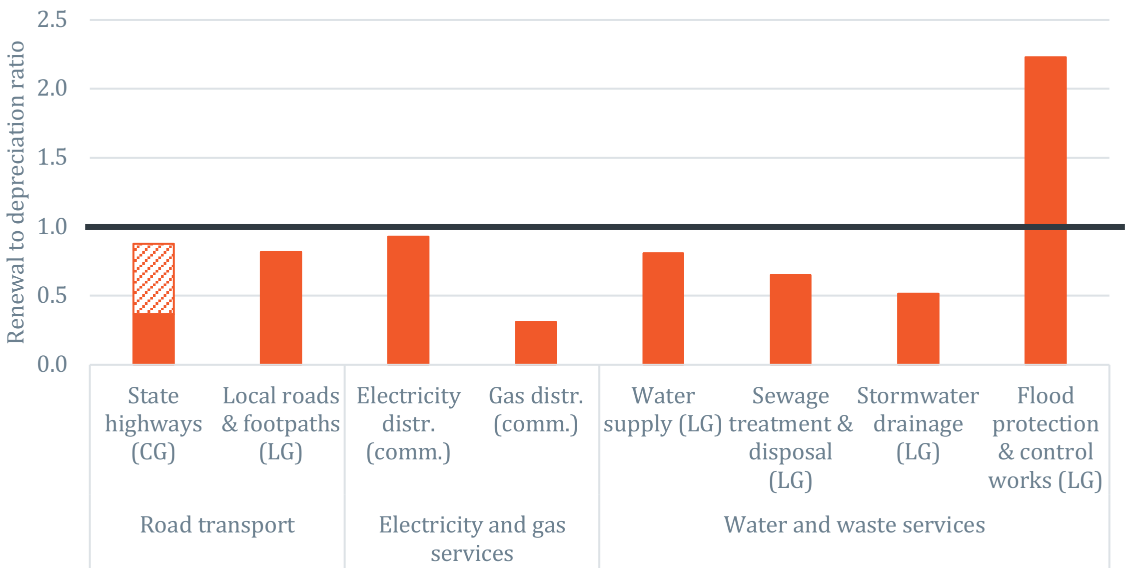
[20] In the case of state highways, we report a range of estimates. The lower end of the range is based on a more conservative estimate of renewal spending, explained in a previous footnote, while the upper end of the range is based on renewal plus maintenance spending. The reason for reporting a range is that, while the lower end of the range is consistent with NZTA's unaudited asset sustainability ratios, the higher end appears to be more consistent with local governments' calculations of their renewal expenditures.

Other infrastructure sectors have renewal-to-depreciation ratios that are far below one:

- State highways (central government): Between 2012 and 2022, state highway renewal spending is estimated to be at least 12% lower than forecast depreciation, and possibly as much as 63% lower.
- Local roads (local government): Forecast 2019–2028 renewal expenditure was expected to be around 18% lower than forecast depreciation.
- Water supply (local government): Renewal expenditure forecast to be 19% below forecast depreciation.
- Sewage treatment and disposal (local government): Renewal expenditure forecast to be 35% below forecast depreciation.
- Stormwater drainage (local government): Renewal expenditure forecast to be 48% below forecast depreciation.

Gas distribution (commercial) have the lowest renewal-to-depreciation ratio, with renewal spending that is covering less than one-third of depreciation expenses. This may reflect asset owners' expectation that gas supply and/or demand will decline in the future, leading to a need to reduce the size of the network in the future rather than continue to invest in maintaining the current network.

Figure 37: Renewal to depreciation ratios for infrastructure sectors



Note: Te Waihanga analysis of data from NZTA, the Department of Internal Affairs, and the Commerce Commission. State highways data is actuals for the 2012–2022 period, with a range that reflects different assumptions about the classification of renewal vs maintenance spending; local government infrastructure data is forecasts for the 2019–2028 period; electricity distribution data is actuals for the 2014–2021 period; and gas distribution data is actuals for the 2017–2021 period.

We couldn't find information for many sectors

Although this data paints a picture of variable performance in different infrastructure sectors, the important thing is that we were able to find and present that information. This is due to regulatory or legislative disclosure requirements, for instance through the Local Government Act, Land Transport Management Act, and the Commerce Act.

We were not able to find comparable data for any types of vertical infrastructure. This prevents us from assessing the adequacy of renewal spending for these sectors. However, in some cases, such as court infrastructure, asset owners have undertaken reviews that suggest that renewal spending is not keeping up with depreciation.[21]

The main reason we are unable to find comparable data for vertical infrastructure is because central government, which is the primary owner of these assets, does not systematically compile and report the relevant data. Likewise, we were not able to find comparable data for horizontal infrastructure networks, like telecommunications infrastructure, that do not face comparable disclosure requirements.

Central government agencies publish asset value and asset depreciation information in their annual reports but are not required to publish financial information on infrastructure asset renewals. Agencies typically report expenditure on maintenance of their assets, but this is not indicative of asset renewals and is difficult to compare to depreciation to gauge whether asset condition is being maintained.[22]

The link between renewal spending and asset condition

Our analysis uses financial measures of capital investment and depreciation as proxies for renewal effort and asset deterioration. However, these values rely on a series of assumptions (outlined in Appendix 1 and Appendix 3), which mean that they may not perfectly reflect actual infrastructure outcomes.

We therefore conclude by analysing the link between renewal spending, the actual quantity of renewal work, and hence to asset condition. To do this, we use data on state highways and local roads, as road infrastructure is one of the few sectors that publishes data on asset condition and renewal work.

Figure 37 suggests that renewal spending is likely to be insufficient to maintain asset condition for both state highways and local roads. Because NZTA publishes data on asset renewal activity and asset condition over time, we can check what has actually happened to assets over this time period.

Road surfaces are relatively short-lived assets, with design lives ranging between 8 and 15 years depending on local conditions (Llopis-Castelló et al., 2020). Pavements need to be resealed at regular intervals to maintain road quality and prevent the need for costly rehabilitation or reconstruction. The percent of road network resealed per year provides an indication of the extent to which resealing activities are sufficient to maintain the quality of the road surface.

[21] https://www.rnz.co.nz/news/national/498847/many-court-buildings-in-very-poor-condition-with-repair-costs-rising-documents-show

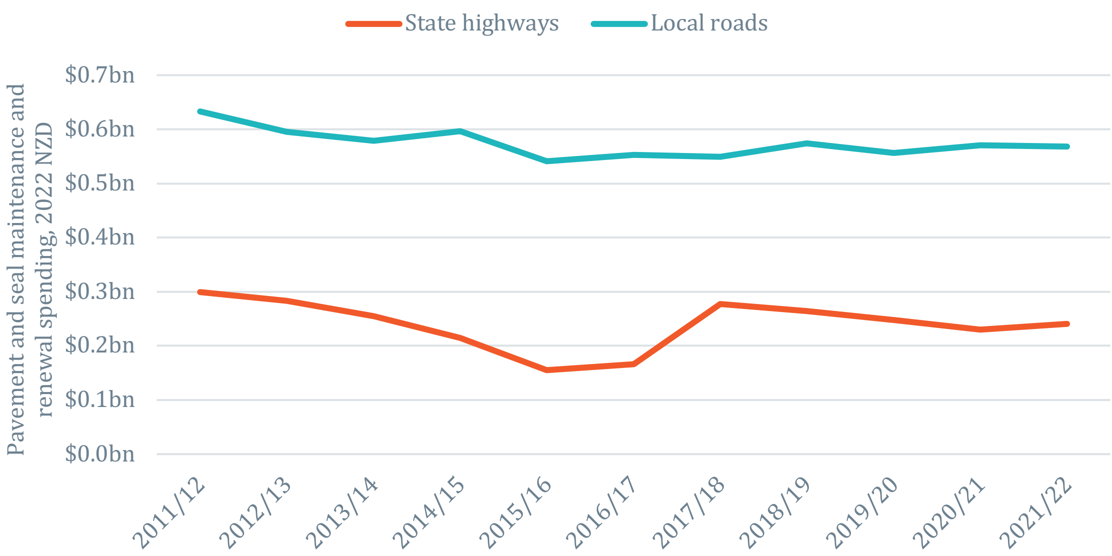
[22] For example, the Ministry of Education's buildings are valued at $24,225 million in their 2023 annual report and had a depreciation expense of $996 million whereas 'maintenance of school property' was just $54 million. Total capital expenditure on buildings was $1,688 million but it is difficult to know how much of this is investment in new infrastructure and how much of this is renewals of existing infrastructure. https://www.education.govt.nz/our-work/publications/annual-report/annual-report-2023/#annualreport2023

Pavement renewal spending has declined in real terms

Figure 38 shows changes in real (inflation-adjusted) spending on pavement and seal maintenance and renewal for state highways and local roads from 2012 to 2022.[23] Between 2012 and 2016, pavement maintenance and renewal spending declined 48% for state highways and 15% for local roads. Overall capital investment in road infrastructure rose 32% over this time, in inflation-adjusted terms. This suggests that reductions in pavement maintenance and renewal spending over this time were due to allocation of funds to other purposes, such as building new roads, rather than reductions in overall road investment.[24]

Pavement maintenance spending increased starting in 2017 but has not fully recovered to previous levels. As of 2022, inflation-adjusted spending remained 20% below 2012 levels for state highways and 10% below for local roads.

Figure 38: Inflation-adjusted pavement and seal maintenance spending, 2012–2022



Note: Te Waihanga analysis of NZTA data

[23] Pavement and seal maintenance accounts for around 40% of overall maintenance and renewal spending for state highways and local roads.

[24] Actual spending on maintenance/renewal versus new or improved infrastructure reflects funding ranges set in the Government Policy Statement on Land Transport. Between 2011/12 and 2021/22, planned state highway maintenance and renewal spending usually fell in the middle of the funding range. State highway maintenance and renewal funding ranges were similar in the 2012 and 2015 Government Policy Statements but increased substantially in the 2018 Government Policy Statement.

Reductions in spending led to a reduction in the amount of resealing work completed

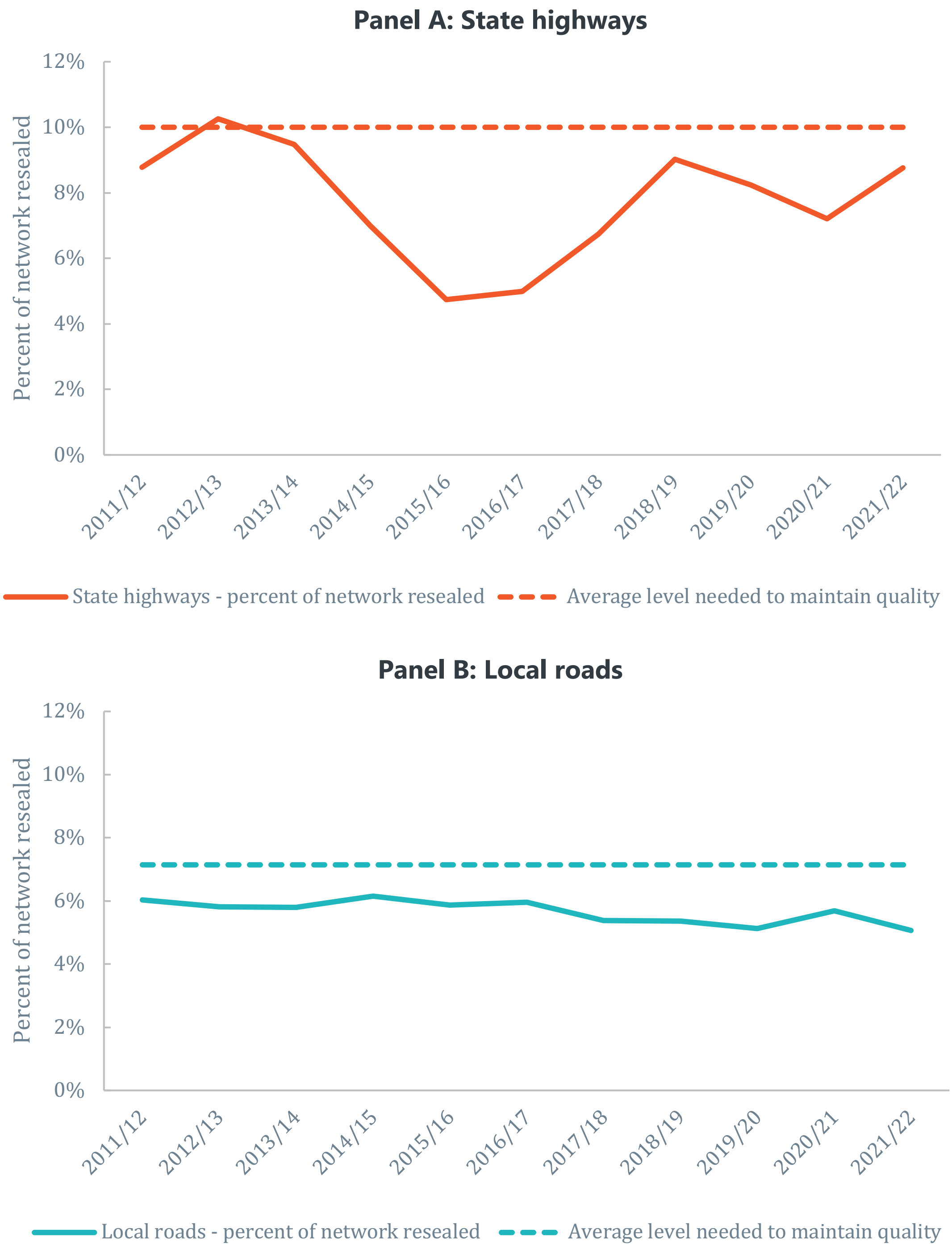
Figure 39 shows compares the share of the road network that was actually resealed every year over the last decade with the share that would need to be resealed in order to maintain current pavement condition.[25]

Panel A shows that the share of the state highway network resealed annually dropped significantly between 2014 and 2016 and rose again starting in 2017. The timing of these changes align closely with the timing of changes in pavement maintenance funding. However, resealing rates have remained below what would be required to maintain current pavement condition.

Panel B shows that the share of the local road network resealed annually has gradually declined over time, consistent with declines in inflation-adjusted pavement maintenance spending. Over the last decade, resealing rates have remained consistently below what would be required to maintain current pavement condition.

[25] We estimate required rates of resealing based on average achieved seal life for state highways and local roads. The average seal life for state highways is 10 years, indicating that around 10% of the network has to be resealed each year to maintain current pavement quality. The average seal life for local roads is 14 years, indicating that around 7% of the network has to be resealed each year to maintain current pavement quality. Local roads tend to have longer seal lives due to generally lower traffic volumes and lower heavy vehicle traffic.

Figure 39: Percentage of networks resealed over time, relative to required levels, 2012–2022



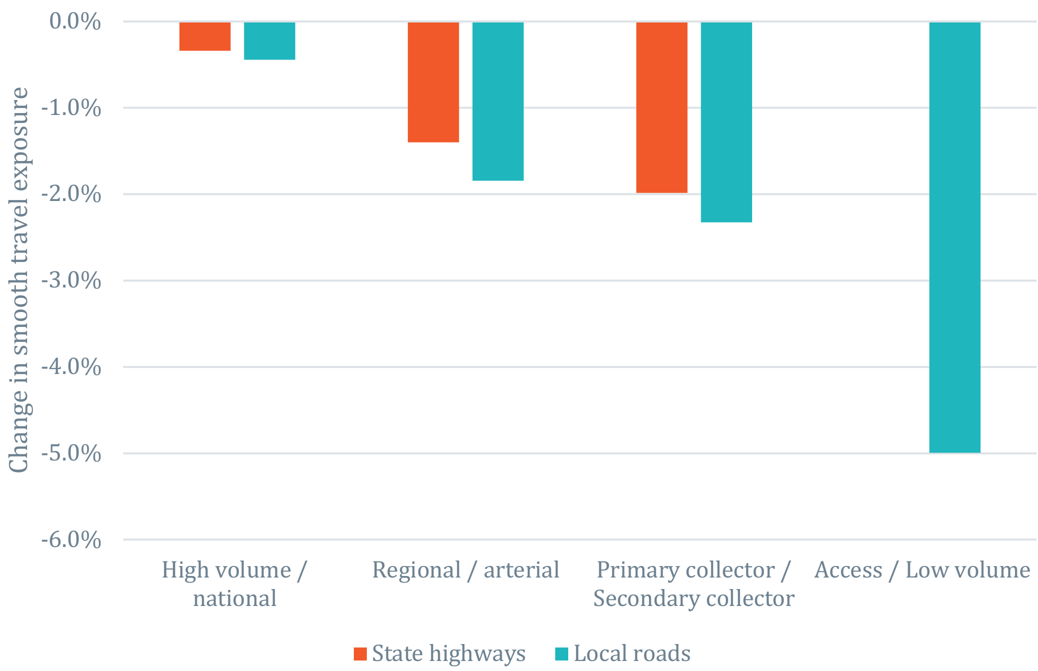
Note: Te Waihanga analysis of NZTA data. Required rates of resealing are based on actual achieved pavement lives for each road category, while observed resealing rates are calculated by dividing lane-kilometres of roads resealed in each year by total network length.

Insufficient resealing rates gradually flow through to declining asset conditions

Reduced resealing activity has led to modest but measurable reductions in the quality of road surfaces. NZTA measures road surface quality using a smooth travel exposure (STE) index, which assesses the smoothness of typical journeys experienced by road users (The Road Efficiency Group, 2019). STE is defined as the percentage of travel on roads that meet smoothness expectations for that road type. This measure is available for both state highways and local roads, broken down by traffic volumes or network function of those roads.

Figure 40 shows that average STE indices declined gradually and modestly for all categories of roads between 2014 and 2022. Average quality declines are larger for roads with lower traffic volumes and low strategic importance, and smaller for roads with higher traffic volumes or regional or national significance. This suggests that asset managers are generally prioritising limited pavement and seal maintenance funding towards road categories with higher levels of use.

Figure 40: Change in average road quality by road category, 2014–2022



Note: Te Waihanga analysis of NZTA data

This analysis demonstrates that there is a link between how much is spent on maintenance and renewal and actual outcomes for asset condition. In the case of road transport, declining pavement and seal maintenance spending has led to a reduction in the volume of resealing work, which has been followed by a gradual decline in asset condition.

However, this analysis also highlights the limits of analysing sufficiency of renewal spending based on financial aggregates. How maintenance and renewal funds are applied can be as important as whether enough is being spent on renewals in the aggregate. By way of analogy, spending $50,000 on a kitchen renovation will not prevent your roof from leaking, even if the cost of the kitchen renovation exceeds what it would have cost to fix the roof.

Conclusion

This *Research Insights* paper provides the first comprehensive and consistent view of the value of New Zealand's infrastructure assets, how much we are investing in them, and how fast they are wearing out. It enables us to understand trends in investment and depreciation across all of New Zealand's infrastructure sectors. We conclude by summarising our key findings and discussing the implications of these findings.

Our key findings

The value of our infrastructure assets is rising over time

The value of New Zealand's infrastructure assets is rising over time. Between 1990 and 2022, the value of infrastructure assets per capita rose from $32,900 to $55,800 in inflation-adjusted terms. This suggests that we have 70% more infrastructure per person than we did a generation ago.

Our infrastructure assets have generally grown in line with the overall size of our economy. In 1990, their financial value was equal to 77% of New Zealand's GDP. In 2022, they were equal to 79% of New Zealand's GDP. What this means is that, as our population has grown larger and wealthier, the size, quality, and utilisation of our infrastructure has also increased.

Asset values have increased more rapidly in some sectors than others. In per-capita terms, we see the most rapid increases for water and waste infrastructure (rising from $2,260 per capita in 1990 to $6,470 in 2022, a 186% increase), other public capital such as libraries, stadiums and convention centres (rising from $810 to $1,870, a 130% increase), transport infrastructure (rising from $7,160 to $14,610, a 104% increase), and public administration, safety, and defence infrastructure (rising from $3,350 to $6,170, an 84% increase). By contrast, we see a smaller per-capita increase for hospitals (rising from $2,340 to $2,750, a 17% increase) and a decrease in the per-capita value of social housing assets (declining from $3,230 to $2,300, a 29% decrease).

In recent decades, we have consistently invested around 5.8% of GDP in infrastructure

Over the last two decades, our overall rate of infrastructure investment has been consistent from year to year. Between 2003 and 2022, gross fixed capital formation in infrastructure ranged between 5.0% and 6.5% of GDP, with an average of 5.8%.

On average, we have invested around 3.4% of GDP in horizontal infrastructure, like transport, water, electricity, and telecommunications, and 2.4% in vertical infrastructure, like schools, hospitals, and public safety and defence. Our largest investment categories were road transport infrastructure (1.1% of GDP), public administration, safety, and defence infrastructure (0.9%), telecommunications (0.7%), and electricity and gas (0.7%).

In 2022, we invested $4,450 per person in infrastructure, including $2,730 in horizontal infrastructure and $1,710 in vertical infrastructure. Because we are investing a roughly constant share of GDP in infrastructure, and because GDP is rising over time, the dollar value of infrastructure investment is rising both in total and in per-capita terms.

Depreciation costs are equal to almost 60% of current investment

We use data on consumption of fixed capital to measure how rapidly our infrastructure assets are wearing out and requiring investment in renewal or replacement. This can help us understand how much of our infrastructure investment needs to be directed towards renewal of existing infrastructure to ensure that asset condition is maintained in the long term.

Between 2013 and 2022, depreciation costs for all types of infrastructure were equal to 58% of capital investment. What this means is that, for every $10 in new and improved infrastructure we purchased, around $6 of existing infrastructure wore out.

This ratio is lower for infrastructure sectors with long-lived assets, like bridges and pipes, and higher for sectors with shorter-lived assets, like buildings and telecommunication equipment. Depreciation costs are equal to 52% of recent capital investment in horizontal infrastructure and 67% in vertical infrastructure.

We don't know if we're currently spending enough on renewals

We are able to compare actual renewal investment with depreciation costs for some, but not all, infrastructure sectors.

Asset owners or regulators published relevant data for three types of horizontal infrastructure (road transport, electricity and gas distribution, and water infrastructure) that represent around 38% of total capital investment in infrastructure. We were not able to find comparable data on any types of vertical infrastructure. This is because central government, which is the primary owner of these assets, does not systematically compile and report the relevant data.

Renewal expenditures appear to be approximately sufficient to cover depreciation costs for electricity distribution and flood protection and control works, but they fall far below this level for state highways, local roads, water supply infrastructure, wastewater infrastructure, stormwater infrastructure, and gas distribution.[26] This suggests that there may be a problem with renewal investment in some areas, but more detailed analysis of renewal activity and asset condition is required to understand whether this is the case.

To illustrate this point, we use data on state highways and local roads to show how the amount of money spent on renewals flows through to the quantity of renewal work and eventually to asset condition. Renewal investment was reduced in the early 2010s, in inflation-adjusted terms, which resulted in insufficient rates of road resealing work. Over

[26] The result for gas distribution may reflect asset owners' expectation that gas supply and/or demand will decline in the future, leading to a need to reduce the size of the network in the future rather than continue to invest in maintaining the current network.

the last decade, the average condition of the road network has gradually declined. Larger declines in condition for lower-traffic roads suggest that asset managers have prioritised limited renewal funds towards the most well-used parts of the network.

Implications of our findings

Infrastructure is an asset for society, but it can be a financial liability for infrastructure providers

In general, increases in the value of infrastructure assets are good for society. More, better, or more well utilised infrastructure can generate broader economic, social, and environmental benefits.

However, infrastructure providers also have to pay to maintain, operate and renew infrastructure assets so they continue to provide benefits to society. As long as we want to continue replacing assets that are wearing out, this is a future liability that we will have to pay at some point.

This is straightforward for the 29% of our infrastructure assets that are provided by commercial or private-sector entities. For the most part, these assets are funded by user charges, meaning that future revenue from the use of these assets can pay for ongoing renewal and replacement. If it does not, it is a signal that the infrastructure is no longer needed.

The situation is different for infrastructure assets that are provided by central government (45% of the total) or local government (26%). These assets often provide important public benefits, and hence tend to be replaced when they wear out, but for the most part they are funded by taxes or rates rather than user charges. As a result, there is no direct revenue stream for renewal and replacement of these assets. Central and local government decision-makers must choose how much money to allocate to renewals, in an environment where there are many competing priorities for funding.

Our current rate of investment sends a strong signal about future investment levels

Following a brief period of low investment in the early 1990s, our rate of infrastructure investment has been extremely consistent. We spend one out of every 17 dollars we earn as a country (5.8% of GDP) on infrastructure investment.

In our previous research, we show that our rate of investment in public infrastructure and in network infrastructure is comparable to other high-income countries (New Zealand Infrastructure Commission, 2021). While lower-income countries tend to spend a larger share of their GDP on infrastructure, this is because they tend to be building new networks from scratch – a process that does not need to be continually repeated (Cubas, 2020).

Our current rate of infrastructure investment sends a strong signal about what levels of investment are likely to be sustainable in the future. If we have consistently invested an average of 5.8% of GDP in recent decades, and if other high-income countries spend a similar amount, then it is reasonable to expect future investment levels, as a share of GDP, to be broadly similar.[27]

This is because our current investment levels reflect a balance between the benefits that New Zealanders perceive from more infrastructure and their willingness to pay taxes, rates, or user charges to fund it. Sustaining higher investment levels in future decades would require us to increase taxes, rates, or user charges, while sustaining lower investment levels would require us to accept lower-quality infrastructure services.

In this context, it may be possible to modestly increase the share of GDP we invest in infrastructure, but it is more likely that we look for ways to change the mix of investment to better meet our future needs. For instance, we may shift investment from schools and universities to hospitals as our population ages or shift investment more towards renewals to ensure that our existing infrastructure continues to function.

Most capital investment should be directed towards renewals, not new infrastructure

To ensure that infrastructure assets are sustainable for future generations, renewal and replacement investment needs to be sufficient to offset depreciation on existing assets. As long as we expect to continue to need infrastructure, we need to spend enough to keep it in good condition.

Based on our current investment levels and rates of depreciation on existing assets, we estimate that around 58% of overall infrastructure investment needs to be directed towards renewal and replacement of assets to accomplish this. Only 42% of our current capital investment is therefore available for building new or improved infrastructure.

Out of the $4,450 per person that we invested in infrastructure in 2022, we needed to spend $2,580 on asset renewal and replacement, leaving only $1,870 per person for new infrastructure. However, the evidence we have gathered suggests that we are not currently investing enough on maintenance and renewal.

In the short term, we have some flexibility around these ratios. For instance, if we need to pay for significant upgrades, we could defer some renewal investment and catch up later on. However, in the long term it is not financially sustainable to underinvest in maintenance and renewal. Well-planned proactive maintenance is typically cheaper than repairing infrastructure after it has started to fail. For instance, reactive road maintenance, which often involves costly pavement rehabilitation, is estimated to cost between 1.5 and 3 times as much as well-planned pavement maintenance (Engel et al., 2020).

We need better information on what we're investing in, as well as how much we're spending

This *Research Insights* paper is a significant step forward for understanding New Zealand's infrastructure assets. For the first time, we have a comprehensive and consistent view on the financial value of assets, investment, and depreciation across all infrastructure sectors.

[27] The dollar value of investment will rise over time as the size of our economy increases, but the share of our income that we spend on infrastructure is likely to be fairly consistent.

However, there are several significant evidence gaps that could be addressed through further work.

First, we lack comprehensive information on the characteristics, quantity, and condition of physical infrastructure assets in most sectors. For instance, while we can say something about the overall value of water infrastructure assets owned by local government, we lack information on what those assets are, where they are, and how well-maintained they are. This makes it difficult to understand how well existing infrastructure assets can meet current and future needs.

Second, while we can measure overall capital investment in infrastructure, we lack comprehensive information on what we're investing in. This makes it difficult to understand the outcomes that are achieved from infrastructure investment.

For instance, the Local Government Act requires local government long-term plans to break down planned investment in asset renewals, new infrastructure to serve demand growth, and improvements in levels of service. This enables us to assess the adequacy of renewal investment for local government infrastructure. However, central government infrastructure providers are not required to compile and report similar data, making it difficult to assess whether they are renewing assets at an adequate rate.

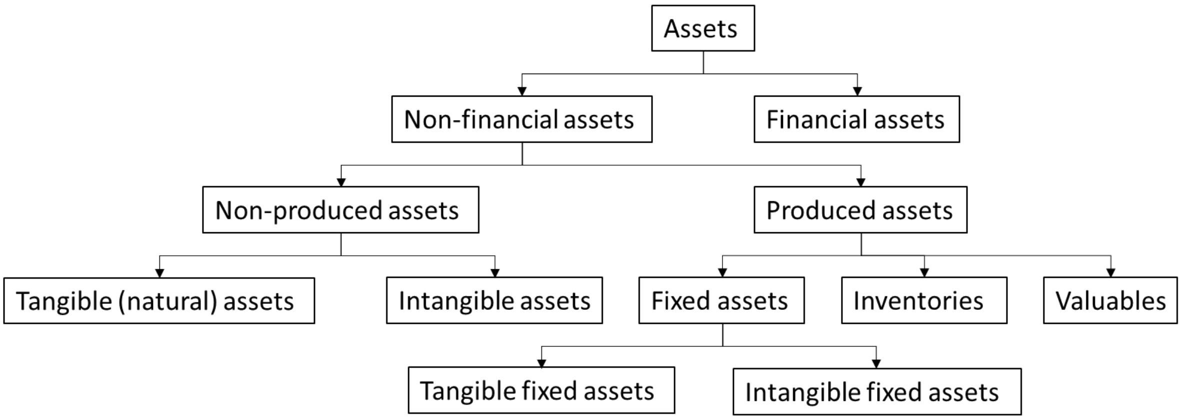
These evidence gaps could be addressed through better asset management planning practices for public sector infrastructure, supported by transparency and disclosure requirements. This is consistent with Recommendation 39 in *Rautaki Hanganga o Aotearoa, the New Zealand Infrastructure Strategy 2022–2052*, which recommends increasing requirements for central government infrastructure providers to undertake and publish long-term planning and asset management planning.

Appendix 1: Measuring capital stock in the New Zealand economy

Defining capital stock

Capital stock is defined as the stocks of fixed assets owned and used by producers in the production process. Stats NZ produces the national accounts for New Zealand, following methodology and definitions from *System of National Accounts* (United Nations et al., 2009).

Figure A1: Classification of assets within the System of National Accounts



Gross capital stock (GKS) is the value of fixed assets held by producers with each asset valued at 'as new' prices over its service life. GKS can be defined as accumulated investment minus the accumulated value of retired assets. GKS is generally only useful as an intermediary variable for calculating net capital stock and productive capital stock.

Net capital stock (NKS) is the depreciated value of fixed assets valued at current replacement cost. NKS can be defined as accumulated investment less accumulated consumption of fixed capital. NKS is the discounted value of the flow of capital services that the assets in existence can produce over the remainder of their service lives.

Productive capital stock (PKS) is a measure of the volume of capital services produced by fixed assets, making allowance for the decline in efficiency as assets age. PKS can be defined as accumulated investment less the accumulated value of the assets retired and less the loss of efficiency of those assets still operating (GKS minus efficiency loss).

Gross fixed capital formation (GFKF)

Gross fixed capital formation is defined as the total value of acquisitions less disposals of new or existing fixed assets during the accounting period. GFKF includes:

- acquisitions, less disposals, of new or existing tangible fixed assets
- acquisitions, less disposals, of new or existing intangible fixed assets
- major improvements to tangible non-produced assets, including land

- costs associated with the transfers of ownership of non-produced assets.

Here 'new' means new to the New Zealand economy and covers not only complete assets but also any renovations, reconstructions, or enlargements that significantly increase the productive capacity or extend the service life of an existing asset.

As per the final bullet point, the value at which the asset enters the balance sheet of its new owner therefore includes the costs of ownership transfer. Disposals are valued at the prices payable by the units acquiring the assets minus any associated costs of ownership transfer incurred by the latter.

Consumption of fixed capital (CFK)

Consumption of fixed capital is the decline, during the accounting period, in the current value of the stock of fixed assets owned or used by a producer as a result of physical deterioration, normal obsolescence, or normal accidental damage. This means changes in capital values due to extraordinary events such as wars or major natural disasters are not included. Real holding gains or losses on assets due to changes in their relative process over the accounting period are also not included.

CFK is measured at current market prices whereas depreciation is measured at the historical cost of the assets. CFK may also include other expenses incurred in purchasing, using, or installing the assets. Depreciation is a method of allocating the costs of past expenditures on fixed assets over subsequent accounting periods. In contrast, CFK is a forward-looking measure. CFK can be thought of as the decrease over the accounting period in the present value of the future rentals expected over the assets remaining service life. This decrease is influenced by:

- the efficiency decline of the asset during the accounting period
- the shortening of an asset's service life
- the rate of efficiency decline of the asset over its remaining service life.

The amount of CFK charged as a cost of production should be sufficient to enable the assets to be replaced.

Asset values may decline because of a decrease in the demand for their services. This drop in expected capital services will be present in CFK. CFK also includes reductions in value resulting from normal, expected rates of obsolescence. It should not include losses brought about by unexpected technological advancements that significantly decrease the service lives of a group of existing fixed assets.

Calculating consumption of fixed capital

There are two ways to calculate CFK:

1. Direct estimation by applying a depreciation function (age-price profile) to the gross value of the asset.

2. Indirectly using age-efficiency profiles to obtain age-price profiles for different types of assets.

Stats NZ uses the second method as this ensures consistency between age-efficiency profiles and CFK. Under method 2 no assumptions are needed about the form of the depreciation function. Instead, assumptions about the form of the age-efficiency profiles and the discount rate are required.

Perpetual inventory method (PIM)

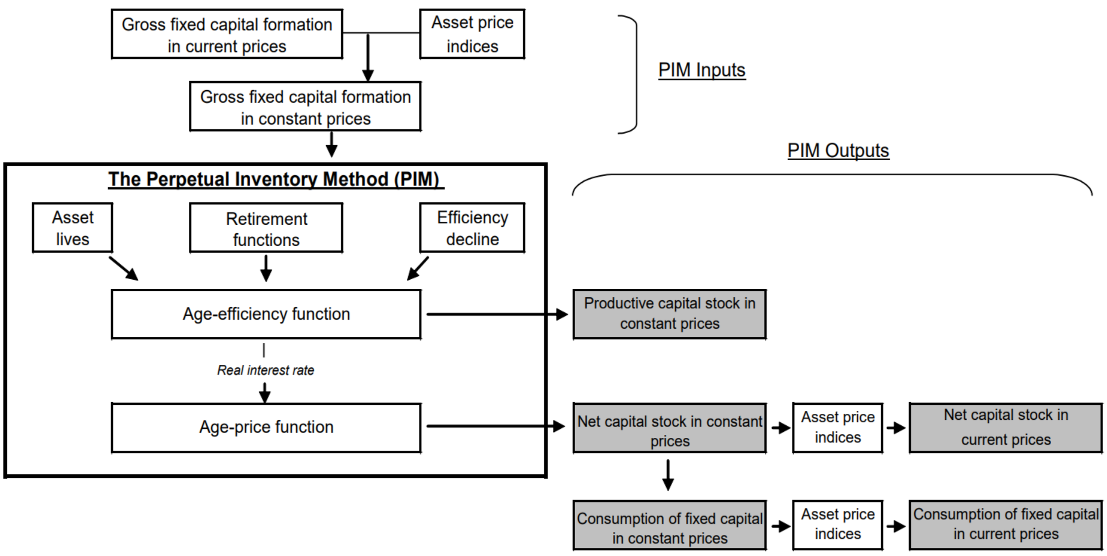
Stats NZ estimate capital stocks using a modified perpetual inventory method (PIM). This modified PIM was pioneered by the United States Bureau of Labor Statistics and is also applied by the Australian Bureau of Statistics. The traditional PIM method:

1. estimates gross capital stock
2. applies a depreciation function to calculate consumption of fixed capital
3. obtains the net capital stock by subtracting accumulated consumption of fixed from the gross capital stock.

This approach makes no explicit allowance for the decline in efficiency as assets age. This decline is instead implicit in the depreciation function. For productivity statistics, GKS needs to be adjusted for efficiency decline. The traditional approach can lead to inconsistencies between net capital stock and productive capital stock estimates.

The modified approach starts by estimating age-efficiency profiles which are then used to derive consistent age-price profiles (depreciation functions). The age-efficiency profiles are then used to calculate the PKS series, and the age-price profiles are then used to calculate NKS series. CFK is then found by differencing the NKS series. All the estimated series are then consistent.

Figure A2: The Stats NZ PIM



Key inputs in the Stats NZ PIM

1. Average asset life assumptions

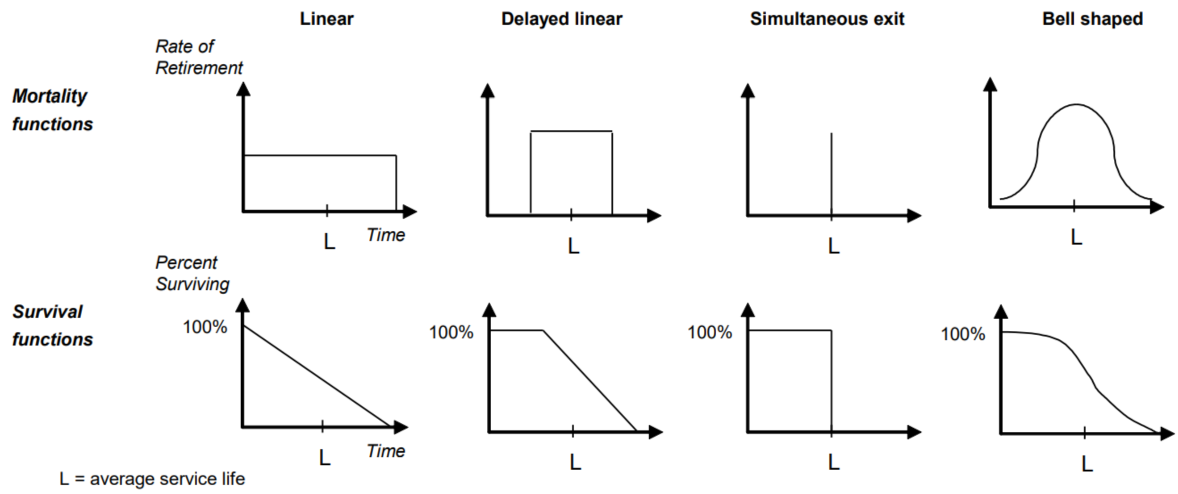
These, together with the retirement functions, determine the length of the input series. A longer life implies slower depreciation, smaller consumption of fixed capital, and a larger estimate of net capital stock. Asset lives are mainly based on a 1992 depreciation survey which Stats NZ carried out on behalf of Inland Revenue.

2. Asset retirement functions

There are two aspects to asset retirement functions: the average life of the asset, and the distribution of retirements about that average age. There is very little empirical evidence around what specific form and shape asset retirement functions take on. Research undertaken by Robley Winfrey in the 1920s and 1930s supports the assumption that assets have bell-shaped retirement functions. Winfrey collected installation and retirement dates for 176 groups of industrial assets and calculated 18 curves that approximate observed retirement patterns. The 18 Winfrey curves provide options for skewness (left-modal, symmetrical, or right-modal) and for kurtosis (a scale from 0 to 7).

The Inland Revenue depreciation survey collected data on the purchase dates and expected service lives for 250 different plant, machinery, and transport equipment asset types. It was found that the L4 Winfrey curve (left-modal with moderately high kurtosis) best fit the retirement patterns for the asset classes 'plant, machinery and equipment' and 'transport equipment'.

Figure A3: Mortality and survival functions



The depreciation survey did not collect data for building and construction assets. Winfrey studied the retirement functions of railway buildings and concluded that they show an R2 Winfrey curve retirement function (right-model with low kurtosis). In the absence of better information, this retirement function is used for 'residential buildings' and 'non-residential buildings'.

Winfrey assigned an L4 function to the retirement pattern for 'brick construction on pavements'. By examining the list of assets that compose this category, it was determined that this was the closest match for the 'other construction' and 'land improvements' asset classes. Accordingly, these asset classes are assumed to have retirement functions that follow an L4 Winfrey curve.

Intangible fixed assets (computer software and 'oil & gas and other exploration') are assumed to follow an L4 Winfrey retirement function. For simplicity, computer software is assumed to retire along-side computers.

3. Age-efficiency and age-price profiles

An age-efficiency profile describes the change in efficiency of an asset as it ages. Efficiency in this context refers to an asset's ability to provide a quantity of capital services. Age-efficiency profiles are created by taking a predetermined rate of efficiency decline and a retirement function. These are then fed into the PIM which estimates an age-efficiency factor for each asset in each year until the asset retires. Age-price profiles are calculated from the age-efficiency profiles using a predetermined discount rate.

Example of calculating an age-price profile

Assumptions:

- The age-efficiency profile has been estimated.
- The asset has a life of 5 years.
- The efficiency deciles from an initial value of 100 by 20 each year.
- A discount rate of 4% is used.

Table A1: Calculating an age-price profile

	Age-efficiency profile	Year 1	Year 2	Year 3	Year 4	Year 5
Year 1	100	100.0				
Year 2	80	$80 / 1.04^{1} = 76.9$	80.0			
Year 3	60	$60 / 1.04^{2} = 55.5$	$60 / 1.04^{1} = 57.7$	60.0		
Year 4	40	35.6	37.0	38.5	40.0	
Year 5	20	17.1	17.8	18.5	19.2	20.0
Total		285.0	192.5	117.0	59.2	20.0
Age-price profile		100	67.5	41.0	20.8	7.0

Table A2: Calculating an age-efficiency profile from an age-price profile

	Age-efficiency profile	Year 1	Year 2	Year 3	Year 4	Year 5
Year 1	23.1 / 23.1 = 100.0	23.1				
Year 2	22.3 / 23.1 = 96.5	21.5	22.3			
Year 3	21.5 / 23.1 = 93.1	19.9	20.7	60-20-18.5 = 21.5		
Year 4	90.0	18.5	19.2	$20.8 / 1.04^{1} = 20.0$	40-19.2 = 20.8	***Start here ↓***
Year 5	86.6	17.1	17.8	$20 / 1.04^{2} = 18.5$	$20 / 1.04^{1} = 19.2$	20.0
Age-price profile		100	80	60	40	20

Age-efficiency profiles

There is little empirical evidence around what age-efficiency profiles should look like. There is small amount of evidence that age-efficiency profiles should follow a hyperbolic function, which is what Stats NZ uses. This implies that asset efficiency declines slowly in early life and at an increasing rate toward the end of the asset's life. Hyperbolic age-efficiency profiles are also used by the United States of America Bureau of Labor Statistics and by the Australian Bureau of Statistics.

The functional form for hyperbolic age-efficiency deterioration is as follows:

$$E_t = \frac{M - A_t}{M - bA_t}$$

Where:
E_t = the efficiency of the asset at time t, compared to its efficiency when new
M = the asset life as per the Winfrey distribution
A_t = the age of the asset at time t assuming that assets are purchased at the end of the year
b = the efficiency reduction parameter

A lower efficiency reduction parameter implies that efficiency decline occurs earlier in an asset's life. Stats NZ set b to 0.75 for 'residential buildings', 'non-residential buildings', 'land improvements', and for 'other constructions'. It is set to 0.5 for 'plant, machinery, and equipment' and 'transport equipment'. It is set to 1 for computers and intangibles implying there is no efficiency decline.

Composite age-efficiency profiles

Assets within a class can have multiple possible 'life paths'. For example, if the retirement function determines that the maximum lifespan for assets within a class is 8 years, then are 8 possible life paths; one where the asset has a lifespan of 1 year, one where the asset has a lifespan of 2 years, one where the asset has a lifespan of 3 years, and so on. Each of these different life paths implies a slightly different age-efficiency profile. For example:

Table A3: Example inputs for calculating a composite age-efficiency profile

Average asset life	4							
Maximum asset life, per Winfrey L4 function	8							
Efficiency reduction parameter	0.75							
End of year	1	2	3	4	5	6	7	8
% of assets retiring during year (from L4)	0	1.84	26	46.28	18.87	6.05	0.94	0.03

Table A4: Calculating life path age-efficiency profiles

Age efficiency profile for year end	1	2	3	4	5	6	7	8
Assets lasting for 1 year	1.000							
Assets lasting for 2 years E_1 = 1 $E_2 = \frac{2-1}{2-(0.75*1)} = 0.800$	1.000	0.800						

Assets lasting for 3 years E_1 = 1 $E_2 = \frac{3-1}{3-(0.75*1)} = 0.889$ $E_3 = \frac{3-2}{3-(0.75*2)} = 0.667$	1.000	0.889	0.667					
Assets lasting for 4 years	1.000	0.923	0.800	0.571				
Assets lasting for 5 years	1.000	0.941	0.857	0.727	0.500			
Assets lasting for 6 years	1.000	0.952	0.889	0.800	0.667	0.444		
Assets lasting for 7 years	1.000	0.960	0.909	0.842	0.750	0.615	0.400	
Assets lasting for 8 years	1.000	0.966	0.923	0.870	0.800	0.706	0.571	0.364

These separate life path age-efficiency profiles are combined into one composite age-efficiency profile by weighting each life path by the retirement function. The composite age-efficiency function for year *j* =$\sum_{j=t}^{m}(E_{jt} * R_t)$ where m is maximum life, E_{jt} is the age-efficiency function of assets lasting for *t* years in year *j* and R_t is the retirement factor for year *t*.

Table A5: Calculating a composite age-efficiency profile

Year end	1	2	3	4	5	6	7	8
Composite age-efficiency profile	100	91.8	76.8	45.8	14.2	3.3	0.4	0.01

The composite age-efficiency profile for year 2 is calculated as:

$$0.800 * 0.0184 + 0.889 * 0.2600 + 0.923 * 0.4628 + 0.941 * 0.1887 + 0.952 * 0.0605 + 0.960 * 0.0094 + 0.966 * 0.0003 = 0.918$$

Whereas the individual age-efficiency profiles take on a hyperbolic shape, the composite age-efficiency profiles more resemble logistic functions with rapid deterioration in efficiency around the average retirement age and slower deterioration at the beginning and end of assets' lives.

Age-price profile

As demonstrated above, each age-efficiency profile can be converted into an age-price profile. The age-price profile for the age-efficiency profile above is:

Table A6: Calculating a composite age-price profile

Year end	1	2	3	4	5	6	7	8
Composite age-price profile	100	71.0	43.6	20.0	5.6	1.2	0.01	0.0

Deriving PKS, NKS, and CFK

These age-efficiency and age-price profiles can then be used to derive consistent estimates of productive capital stock, net capital stock, and consumption of fixed capital from data on gross fixed capital formation.

Table A7: Deriving capital account figures

Year end	GFKF (constant prices)	Age-efficiency profile	PKS (constant prices)	Age-price profile	NKS (constant prices)	Annual CFK
1	1000	100.0	1000	100.0	1000	0
2		91.8	918	71.0	710	290
3		76.8	768	43.6	436	274
4		45.8	458	20.0	200	236
5		14.2	142	5.6	56	144
6		3.3	33	1.2	12	44
7		0.4	4	0.01	0.1	11.9
8		0.01	0.1	0.0	0	0.1

Appendix 2: Infrastructure sectors

Table A8: Classification of sectors and industries into infrastructure types

Sector of ownership	ANZSIC Industry	Infrastructure type	Vertical or horizontal
Central Government	Road Transport and Postal, Courier, Transport Support, and Warehousing Services	Central Government Road Transport	
Local Government	Road Transport and Postal, Courier, Transport Support, and Warehousing Services	Local Government Road Transport	
Central Government	Rail, Water, Air and Other Transport	Central Government Other Transport	
	Construction		
Non-Government – 2M (KiwiRail)	Rail, Water, Air and Other Transport		
Local Government	Rail, Water, Air and Other Transport	Local Government Other Transport	Horizontal
	Construction		
All Sectors	Electricity and Gas Services	Commercial/Private Electricity and Gas Services	
Local Government	Water, Sewerage, Drainage and Waste Services	Local Government Water and Waste Services	
Commercial/Private	Water, Sewerage, Drainage and Waste Services	Commercial/Private Water and Waste Services	
Commercial/Private	Telecommunications, Internet and Library Services	Commercial/Private Telecommunications Services	
Central Government	Preschool and School Education	Central Government Preschool and School Education	
Commercial/Private	Preschool and School Education	Commercial/Private Preschool and School Education	Vertical
Central Government	Tertiary Education	Central Government Tertiary Education	
Commercial/Private	Tertiary Education	Commercial/Private Tertiary Education	

Central Government	Hospitals	Central Government Hospitals	
Commercial/Private	Hospitals	Commercial/Private Hospitals	
Central Government	Public Administration and Safety	Central Government Public Administration and Safety	
Local Government	Public Administration and Safety	Local Government Public Administration and Safety	
Central Government	Property Operators and Real Estate Services	Central Government Social Housing	
Non-Government – 2M Only (Kāinga Ora)	Property Operators and Real Estate Services		
Local Government	Property Operators and Real Estate Services	Local Government Social Housing	
Central Government	Telecommunications, Internet and Library Services	Central Government Other Public Capital	
	Healthcare and Social Assistance (excluding hospitals)		
	Arts, Recreation and Other Services		
Central and Local Government	Adult, Community and Other Education		
Local Government	Telecommunications, Internet and Library Services	Local Government Other Public Capital	
	Arts, Recreation and Other Services		

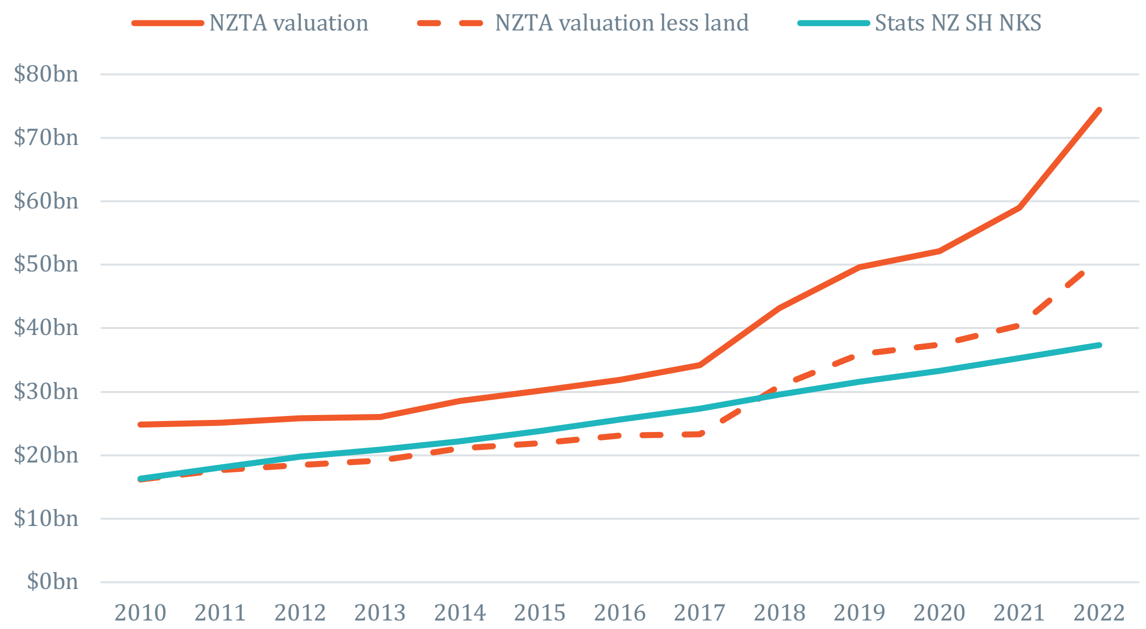
Note: Our custom data request separates out two significant state-owned infrastructure providers, Kāinga Ora and KiwiRail. We have grouped these entities' infrastructure as central government social housing infrastructure and central government rail, water, air and other transport respectively. Other state-owned enterprises fall under local or central government in specific infrastructure sectors.

Appendix 3: Different sources for the value of New Zealand's infrastructure

While Stats NZ's capital accounts are our main source for the value of New Zealand's infrastructure, other sector-level information exists. One key source is NZTA that publishes information on their valuation of New Zealand's state highway network along with information on renewals expenditure and depreciation charges through their annual reports.

Both Stats NZ's net capital stock valuations and NZTA's valuations are advertised as 'replacement costs' (the estimated cost to replace the existing assets with similar condition assets). Figure A4 shows NZTA's valuation of the state highway network and Stats NZ's estimate of the net capital stock value of state highways.

Figure A4: Different valuations of New Zealand's state highway network, nominal $NZD



Between 2011 and 2017 Stats NZ's net capital stock valuations of the state highway network were around 80% of NZTA's valuation of the state highway network. This changed in 2018 and the two valuations have diverged to the point where in 2022 Stats NZ's valuation was half that of NZTA's.

As mentioned at the beginning of this report, land is not included in NKS. When land is removed from NZTA's valuation we see that it is much closer to Stats NZ's valuation. The two valuations appear to diverge from 2018 as NZTA's valuation increases faster than Stats NZ's valuation.

NZTA's annual reports from the 2017/18 report through to the 2021/22 report all cite movements in unit price rates reflecting the current costs of construction and increases from land revaluations as key drivers in increasing the valuation of the state highway network. As these are estimated replacement costs, increases in the cost to build or buy any of the components of state highways would therefore increase the valuation. The recent divergence from the Stats NZ NKS valuation suggests that NZTA believes that road construction costs are inflating much faster than Stats NZ believes they are.

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