
# Smart Cities

# Strategic Assessment

V1.0 – 14 December 2016

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# How to use this document

This Strategic Assessment provides the rationale for New Zealand territorial authorities to invest in the development of smart cities in their community. It is designed to support the aspiration of New Zealand communities to build better and more resilient human ecosystems – to ensure their neighbourhoods and cities are better places to live, play and work.

This document has been developed by Land Information New Zealand (LINZ) to assist writers to prepare business cases for investment in specific Smart Cities initiatives, as part of the Better Public Services development initiative, funded by the NZ Treasury. Information on how to integrate this Strategic Assessment into a business case is contained in a separate How-To Guide document.

## Audiences

There are two intended audiences for this document:

- Business case writers who wish to assess the merits of investing in specific Smart Cities technologies in New Zealand
- Policy developers and decision makers who are considering the merits of investing in specific Smart City initiatives, or who are developing policy to guide the development of sensing technologies.

## Developing investment business cases

This document forms the first section of the New Zealand Treasury best practice Better Business Case (BBC) methodology – the Strategic Assessment. The purpose of the business case methodology is to present a proposed investment in five cases, to demonstrate that:

- It is supported by a robust case for change – the 'strategic case'
- It optimises value for money – the 'economic case'
- It is commercially viable – the 'commercial case'
- It is financially affordable – the 'financial case'
- It is achievable – the 'management case'

This Strategic Assessment is designed to answer the "why" question posed by a proposed investment in Smart Cities. It outlines the international and New Zealand-specific context, describes the current state of our cities and the challenges they face, and explores a possible future state for how cities can become more responsive to the needs of their citizens, more efficient to operate and more environmentally sustainable.

The intention is that this document will form the first case in subsequent business cases that are assessing specific investments. Rather than each business case writer having to start with a blank sheet of paper and write the Strategic Assessment from first principles, the intention is that this document can be copied and pasted into the appropriate section of the business case, and then modified to suit the specific requirements of the investment being proposed.

# The How-To Guide

In addition to the Strategic Assessment, LINZ has prepared a How-To Guide for using it effectively when writing Smart Cities business cases, intended for use by business case writers. The purpose of the How-To Guide is to provide supplementary material and guidance that is specific to the types of investments that local and central government are likely to make in Smart Cities.

The How-To Guide does not provide any guidance for writing business cases in the general sense. As noted above, it's expected that business case practitioners will have an understanding of the Better Business Case methodology and approach, and further guidance – along with links to relevant training courses and material – is available from the New Zealand Treasury website:
http://www.treasury.govt.nz/statesector/investmentmanagement/plan/bbc

# Strategic context

The development of key information and communication technologies such as distributed computing, powerful and intuitive hand-held devices, cloud processing and storage, mesh networking and low-cost sensors is presenting opportunities to re-think how cities are designed, occupied and managed. Together, these technologies are enabling new and innovative approaches to the design, operation and renewal of our urban environments, and to their environmental impact.

In turn, cities need to respond to the changing demands of their populations. Humanity is continuing to urbanise, and projections show that 66% of us will be living in cities by 2050 – a sea-change from our largely agrarian societies of only 60 years ago, when two thirds of us lived in rural settlements. Making sure that our existing and new urban centres are healthy, efficient, productive and environmentally sustainable is one of the key challenges for this century, and the use of appropriate technologies is a key way of addressing those challenges.

Cities are already beginning to grapple with these challenges. As populations age, there will be a drive for lower spending and more affordable local taxation, at the same time that key infrastructure renewals need to take place and investments need to be made. In addition, while some cities will face pressures from growing populations, other urban areas will be challenged by declining numbers, which will force difficult decisions about which assets to preserve with a falling taxation base.

The investments that are beginning to turn urban environments into Smart Cities rest on four key principles: that the cities of tomorrow need to be efficient, environmentally sustainable, resilient and able to deliver the social outcomes expected by their citizens.

New Zealand already leads the world in some of our deployments of Smart City technologies, and in integrating them with the way we inhabit our urban landscapes. Both local and central government are continuing to invest in this fast-changing area, and the purpose of this document is to set out why this is both a prudent and a necessary step in addressing the country's 21st Century challenges.

## The global context

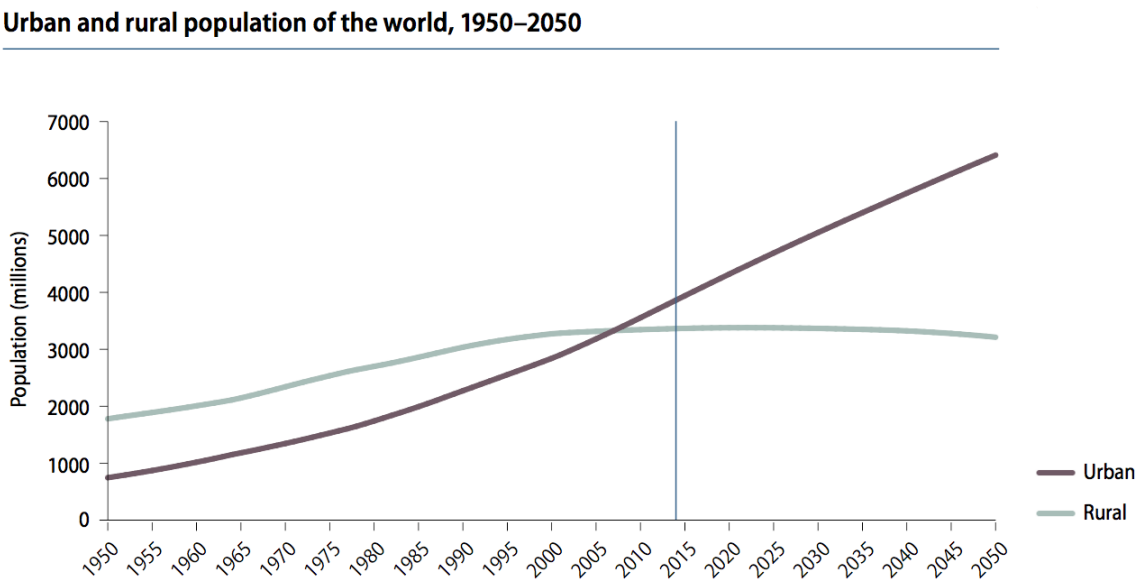
### Urbanisation trends

> The 19th century was a century of empires. The 20th century was a century of nation states. The 21st century will be a century of cities.
>
> *- Wellington E. Webb, former Mayor of Denver*

Cities are the manifestation of the cultural, economic and social acceleration that we have experienced in our modern history. In 2007, for the first time in history, the global urban population exceeded the global rural population, and the world population has remained predominantly urban thereafter. By 2050, more than 6 billion people will be living in the messy, burgeoning atmosphere of urbanised areas.

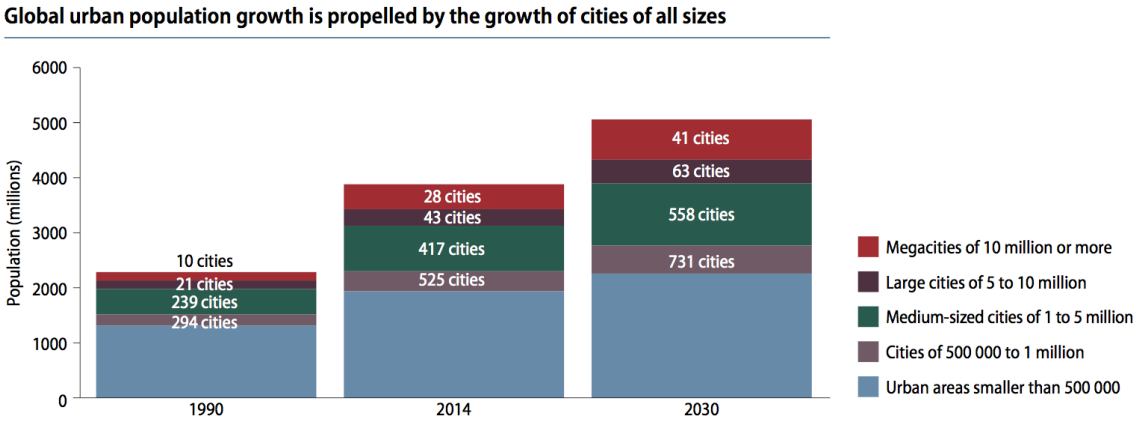
According to the United Nations, the rural population of the world has grown slowly since 1950 and is expected to reach its peak within a few years. The global rural population is

now close to 3.4 billion and is expected to decline to 3.2 billion by 2050. The urban population of the world has grown rapidly since 1950, from 746 million to 3.9 billion in 2014. Continuing population growth and urbanisation are projected to add 2.5 billion people to the world's urban population by 2050:




*Source: World Urbanization Prospects Report 2014, Department of Economic and Social Affairs, United Nations, ISBN 978-92-1-151517-6*

Cities of all sizes are growing, in all regions of the world. While some urban areas in developed countries are expected to peak in coming decades as their citizens age and the total population stagnates and then begins to fall, both the number of cities and their sizes will continue to grow as the trend to urban living continues:



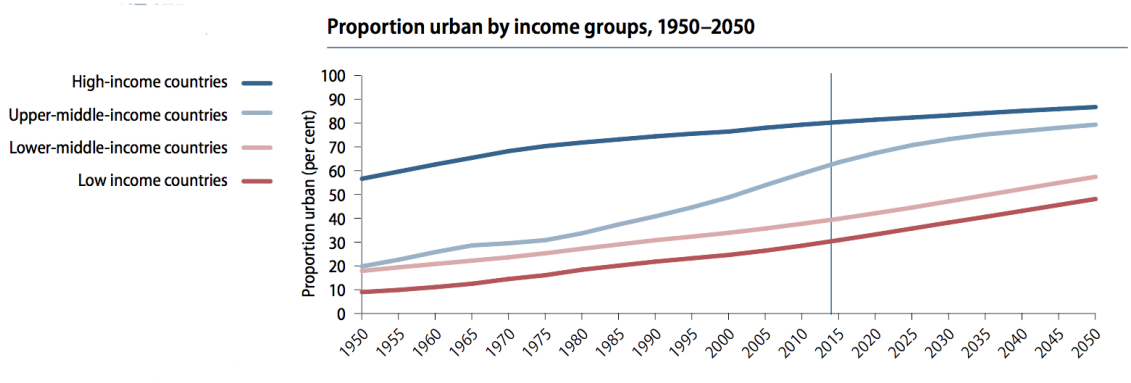

*Source: United Nations, ibid*

One in five urban dwellers worldwide lives in a medium-sized city with 1 million to 5 million inhabitants – comparable in size to Auckland. In 2014 close to one half of the world's urban population lives in settlements with fewer than 500,000 inhabitants, in urban centres comparable in size to Christchurch or Wellington.

## The benefits of and drivers for urbanisation

The process of urbanisation has historically been associated with other important economic and social transformations, which have brought greater geographic mobility, lower fertility, longer life expectancy and population ageing. Cities are important drivers of development and poverty reduction in both urban and rural areas, as they concentrate much of the national economic activity, government, commerce and transportation, and provide crucial links with rural areas, between cities and across international borders.

Since 1950, it's clear that rural push factors such as agricultural modernisation and rural poverty, combined with urban pull factors such as industrialisation and urban-biased policies have both contributed to urbanisation. The effect of urbanisation trends across different countries can be seen in the following graph:




*Source: United Nations, ibid*

From an individual's standpoint, there are significant drivers towards urbanisation. These include better job prospects, better health care provision, improved transportation linkages and wider social and cultural opportunities compared to the regions. These are all valid reasons for individuals and families to make the decision to move to urban centres.

Urban living is often associated with higher levels of literacy and education, better health, greater access to social services, and enhanced opportunities for cultural and political participation. Urbanisation is integrally connected to the three pillars of sustainable development; economic development, social development and environmental protection.

As the world continues to urbanise, sustainable development challenges will be increasingly concentrated in cities, particularly where the pace of urbanisation is fastest. At the same time, cities offer opportunities to expand access to services, such as health care and education, for large numbers of people in an economically efficient manner. Providing public transportation, as well as housing, electricity, water and sanitation for a densely-settled population is typically cheaper and less environmentally damaging than providing a similar level of services to a predominantly rural household. Urban dwellers also have access to larger and more diversified labour markets, and enjoy healthier lives overall.

## The challenges

While it can be advantageous from an individual perspective to relocate to a city, urban centres have some unique challenges. According to the United Nations World Urbanisation Prospects Report 2014[1], the key policy challenges for urbanising populations are:

> **Governments must implement policies to ensure that the benefits of urban growth are shared equitably and sustainably**. Cities can lead the way towards economically, socially and environmentally sustainable societies, but a holistic approach to urban planning and management is needed to improve living standards of urban and rural dwellers alike. Sustainable urbanisation requires that cities generate better income and employment opportunities, expand the necessary infrastructure for water and sanitation, energy, transportation, information and communications; ensure equal access to services; and preserve the natural assets within the city and surrounding areas.
>
> **Diversified policies to plan for and manage the spatial distribution of the population and internal migration are needed.** History has shown that policies that aim to restrict rural-urban migration are ineffective at forestalling city growth, and can even produce economic, social and environmental harms. In recent years, a growing number of countries have been favouring other strategies for rural and urban development, such as allocating land rights, managing land use, land redistribution, creating regional development zones and promoting economic diversification and competitiveness in rural areas through the mobilization of investment and the improvement of rural livelihoods.
>
> **Policies aimed at a more balanced distribution of urban growth**, avoiding excessive concentration in just one or two very large urban agglomerations within a single country, can also support sustainable development. These policies, as well as those promoting the growth of intermediate-size cities, can help to address the problems of excessive centralisation of economic and administrative functions, while also responding to the challenges of providing urban infrastructure and basic social services, and mitigating the negative environmental impacts often associated with large and rapidly growing urban agglomerations.
>
> **Accurate, consistent and timely data on global trends in urbanisation and city growth** are critical for assessing current and future needs with respect to urban growth and for setting policy priorities to promote inclusive and equitable urban and rural development. In order to systematically track levels and trends in urbanisation around the world and to monitor progress in sustainable development goals in urban and rural areas, governments should continue their efforts to produce more extensive and better quality data on the size, distribution and characteristics of their population.

[1] World Urbanization Prospects Report 2014, Department of Economic and Social Affairs**,** United Nations, ISBN 978-92-1-151517-6

> **Successful sustainable urbanisation** requires competent, responsive and accountable governments charged with the management of cities and urban expansion, as well appropriate use of information and communication technologies (ICTs) for more efficient service delivery. There is a need for building institutional capacities and applying integrated approaches in order to attain urban sustainability.

According to the Sustainable Urbanisation Policy Brief, urban centres currently occupy less than 5% of the world's landmass, whilst accounting for around 70% of both global energy consumption and greenhouse gas emissions – and increasing the size and population of existing cities tends to exacerbate these issues. Innovation in urban infrastructure and technology is therefore essential when thinking about how the growth in urban population in coming decades can be accommodated.

While urban centres can and do provide societal benefits at the aggregate level, they can also create social and wellbeing challenges at the community and individual level. These range from poor living conditions to overcrowding, unhealthy environmental conditions, exposure to crime and social dislocation.

These wellbeing challenges create significant pressures on both the physical and social infrastructure of cities – and when left untreated, can result in considerable societal dysfunction. Addressing the social aspects of increased urbanisation is therefore a key requirement in building sustainable communities.

Even where the need for further investment is obvious, cities cannot always fund the level of infrastructure needed to support both increasing numbers of people and growing citizen expectations. To grow efficiently whilst preserving good quality of service, effective utilisation of existing resources and infrastructure will be required, along with high-quality investment decision making.

The capability of Smart Cities technologies to provide real-time situational data about the urban environment allows cities to be actively monitored and managed. This can result in improved efficiency, lowered environmental impact, better quality of service, and safer communities for citizens.

## The climate change imperative

The effects of anthropogenic climate change are an increasingly urgent issue for humanity, and due to rapid urbanisation, a majority of the global population will experience the impacts of climate change in cities. Climate change will exacerbate the existing environmental management challenges in urban centres – in most cases making existing problems much worse.

For instance, a recent study led by World Bank economist Stephane Hallegatte and the OECD, forecasts that average global flood losses will multiply from $6 billion per year in 2005 to $52 billion a year by 2050 with just social-economic factors, such as increasing population and property value, taken into account. Add in the risks from sea-level rise and sinking land, and global flood damage for large coastal cities could cost $1 trillion a year if cities don't take steps to adapt.

Most coastal cities' current defences against storm surges and flooding are designed to withstand only current conditions. They aren't prepared for the rising sea levels

accompanying climate change that will make future floods more devastating. Protecting these cities in the future will take substantial investment in structural defences, as well as better planning.

However, while coastal defences reduce the risk of floods today, they also attract population and assets into the protected areas and thus put them at risk in case of the defence fails, or if an event overwhelms it. This was seen in New Orleans, where decades of investment in heroic flood protection schemes led to high population density in an area that was ultimately overwhelmed by Hurricane Katrina, magnifying the human and economic disaster that resulted.

Cities have always had to respond to the vagaries of their local climate. However, climate change brought about by anthropocentric greenhouse gas emissions will likely be greater in complexity and scale than anything cities have had to address in the past, due to both the extent and the rapidity of the changes.

As the World Bank points out[2]:

> Cities are particularly vulnerable to the impacts of climate change in that they are immobile. Infrastructure such as bridges, subway systems, buildings, and roads, the historic sense of place, and rootedness of residents are critical attributes of cites. These strengths of place can, however, become liabilities if the local ecosystems that they are based on are unable to adapt to climate-induced changes. Climate change poses serious threats to urban infrastructure, quality of life, and entire urban systems. Not only poor countries, but also rich ones will increasingly be affected by anomalous climate events and trends.

In order to respond effectively, cities will need to integrate climate change into an already full agenda of basic service provision, usually with insufficient funding. Though cities are vulnerable to the effects of climate change, they are also uniquely positioned to take a global leadership role in both adapting to it and mitigating the impact from emissions.

As Jeffrey Sachs, Director of the Earth Institute at Columbia University noted:

> Adaptation and mitigation are two interrelated aspects of the climate change puzzle.
>
> **Adaptation** – Human-induced climate change is already underway and will intensify in the coming decades. Cities will be threatened in several major ways, and every city must plan ahead to confront, manage, and where possible, fully head off the growing risks. Heat waves will threaten lives of vulnerable populations such as the elderly. Droughts, floods, and other natural hazards will become more frequent, though the vulnerability of specific cities will vary widely depending on their physical geography, climatology, level of economic development, the quality of governance, social cohesion, and the financial capacity to adjust. Rising sea levels may play havoc with coastal cities,

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[2] World Bank. 2010. Cities and Climate Change : An Urgent Agenda. Urban development series; knowledge papers no. 10. Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/17381 License: CC BY 3.0 IGO."

submerging some areas, and making others far more vulnerable to storm surges, or adversely impacting key infrastructure.

**Mitigation** – The other major challenge is climate change mitigation: reducing humanity's greenhouse gas emissions in order to slow and eventually to stop or even reverse the human impacts on the climate. Mitigation is every bit as complex as adaptation, and often the two are closely intertwined. Green buildings can both reduce energy use and increase resilience to heat waves and other climate hazards. Mitigation will require major long-term changes to energy systems, the design of buildings, transport networks, and urban spatial patterns and zoning. Changing these fundamental attributes of cities will often involve making deep changes in the fabric of city life and its underlying economics. The task of mitigation, essentially moving to a low-carbon society, will have to be carried out in thousands of cities around the world, and will require decades of persistent and creative policymaking to achieve.

Smart Cities technologies can facilitate both adaptation and mitigation. Real-time monitoring of water levels, infrastructure stresses and environmental parameters can enable cities to adapt in real-time to adverse natural events, while sensors can also allow cities to operate in a way that reduces their carbon emissions. Both approaches will be necessary to respond effectively to the challenges of anthropogenic climate change.

How cities are structured – in the patterns of residential settlements, commercial and industrial land use, energy systems, transport networks, water and sewerage infrastructure, public health management, and more – will not only determine the quality of life of the majority of the world's population, but also whether humanity, at long last, is able to live sustainably with nature. The scale, scope, and complexity of the challenge will rival any that humanity has faced in recent centuries.

## The national context

New Zealand is not immune to the social, political, technological and environmental changes that are driving increased urbanisation across the world. The social and economic dynamics that are causing people to want to live in large urban centres are felt just as strongly in Aotearoa – from greater job and educational opportunities through to wider cultural and social interactions.

There are two specific challenges for New Zealand:

- Some of our urban centres are growing, and doing so quite rapidly, in order to accommodate population shifts and preferences, and as a result of relatively high immigration from both new residents and New Zealanders returning from living overseas
- Some of our regional centres have plateaued and will begin declining as people move to larger centres and as the local population ages in the decades ahead.

Demographic changes underlie these trends. By 2045 another 1.2 million people are projected to live in New Zealand. However, this increase will not be evenly spread across the country.

Some 92 percent of this growth will be across just five regions, and over 60 percent is likely to be in just one region: Auckland. This growth will create infrastructure pressures in housing, urban infrastructure, the 3-waters and roads. The following diagram shows that by 2038 most populations in larger regions (over 80,000) are projected to increase. Three will stay the same and one – Lower Hutt City – is projected to decrease. From 2038 to 2043 growth is projected to continue to grow but more slowly slightly in larger regions.

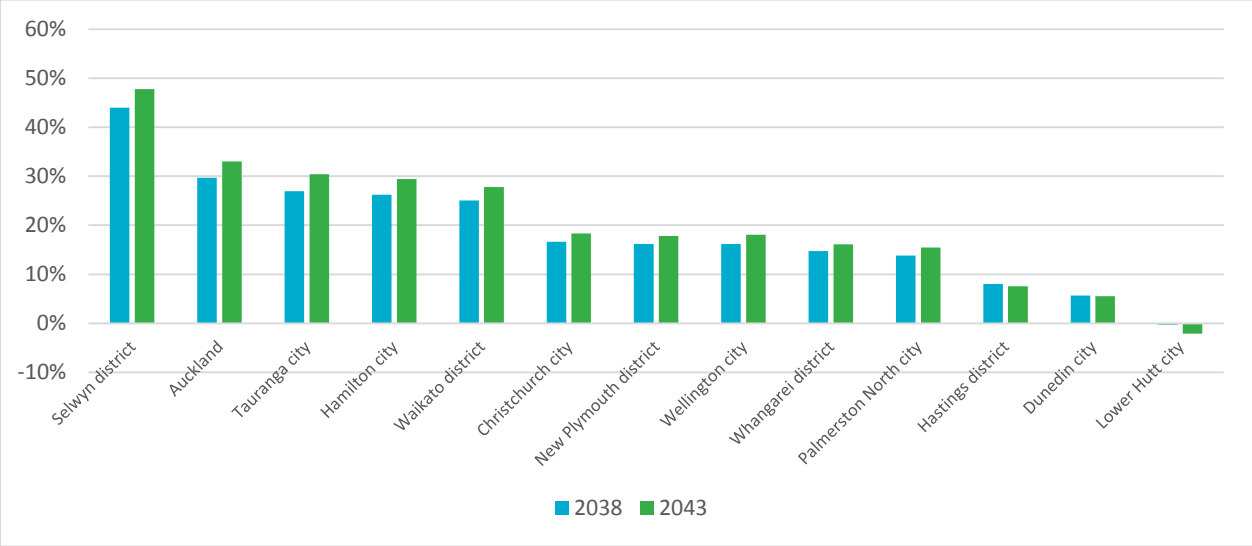



**Figure 1: Population changes for regions over 80,000- 2038 then to 2043 (source Statistics NZ)**

These changes mean that a lot of the infrastructure assets built up over the last century are in the wrong place, and not right sized for the populations they serve now and in the future. Planning for their efficient use and re-use will become a priority in the decades ahead. From an all-of-NZ perspective, it is important that the right cities grow in the right way – there is such a thing as bad urban growth, as it is very time consuming and expensive to set it right.

In addition, there are external challenges for New Zealand's urban centres. Growing and changing populations put pressure on ecosystem sustainability, and some of these issues – such as the availability of water supplies, or sea level rise – will become more acute under the impact of climate change. A high level of adaptability is therefore desirable for all our urban centres, and greater efficiency is needed to reduce the environmental footprint that comes from a large number of people living in an urban centre.

## The challenge of growth

As the growth of Auckland since the end of WWII has shown, there are very real pressures that come from making our cities bigger and more expansive. And there can be significant negative impacts on the lives of people who live in them from unconstrained growth, from increasing commuting times to rising house prices, as well as the pressures that are placed on infrastructure such as roads, power, water supplies and ICT systems.

People move to cities – particularly large cities – in the expectation that their lives will be better. However, this is by no means a given; despite the additional economic

opportunities that urbanisation brings, there are also challenges in social dislocation, the lack of immediate community support and potential exposure to crime that may not exist in smaller centres. Addressing these issues requires a multi-dimensional approach, along with accurate information about people and their living environments.

The growth of a city – particularly at its outer boundary – can be expensive in infrastructure and environmental terms. Adding the additional roading, power, three waters and telecommunications required by a new development at the edge of a city can impose significant costs on local authorities and central government, which will be reflected in the rates and taxes paid by citizens.

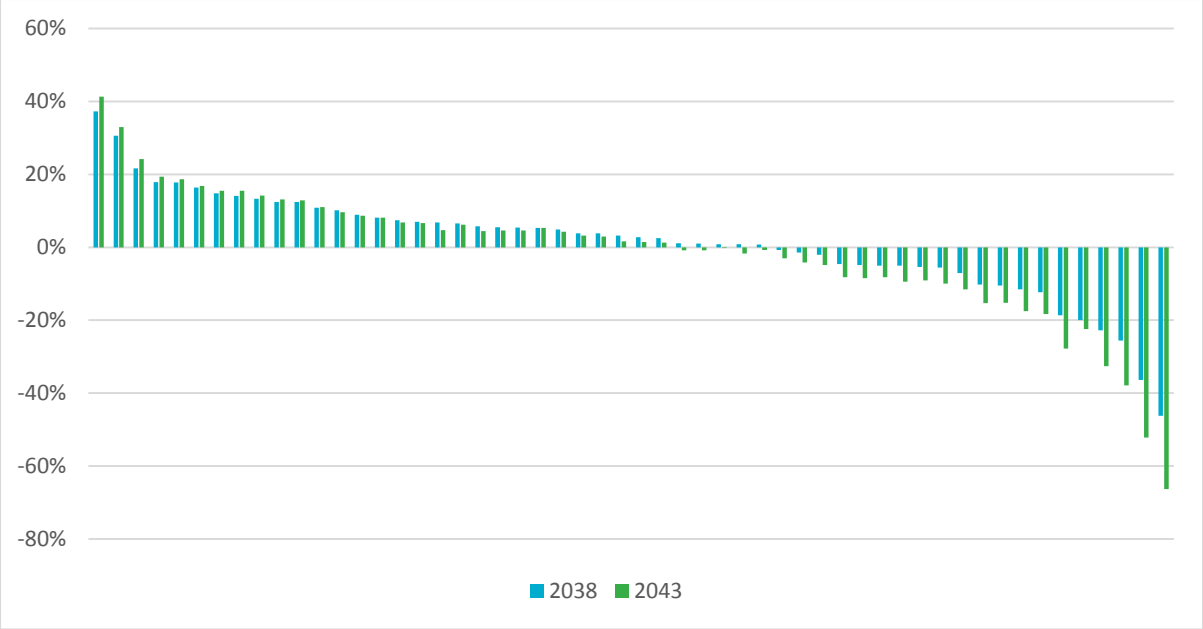
The marginal cost of adding new infrastructure will always exceed the marginal cost of making more efficient use of the infrastructure that already exists. This is a fundamental driver for having better information about a city, its infrastructure and the demands placed on it by citizens, as it allows infrastructure investments to be correctly targeted, and for operational management to optimise the use of the infrastructure that already exists.

In addition, the encroachment of cities into productive farmland negatively impacts the rural economy, and can reduce the environmental carrying capacity of the region. Making more efficient use of existing infrastructure is a key way of reducing this negative impact.

## The challenge of decline

New Zealand is going to face a range of demographic changes as our population ages. Some of our smaller regional centres have plateaued in population, and a number will begin to decline in size in the decades ahead.

The populations of a significant number of smaller centres is expected to decrease materially in coming decades. The following diagram shows that for regions under 80,000 people, about half of those regions will show some decline in population; from 2038 to 2043 the population of two-thirds of these regions will decline in absolute terms. This is due to both an aging population and the continuation of the trend for people to move to our largest centres.




This trend will result in different pressures, as smaller numbers of people will need to decide which of the community assets built up in preceding generations should be retained, and which should be discarded.

Local communities may not be interested in maintaining roads that are underutilised or kindergartens that are mostly empty, but they are unlikely to be happy with public infrastructure simply falling into rack and ruin. In this context, high quality information about the infrastructure and the usage patterns of its users will be critical in making informed decisions.

## The challenge of changing environments and natural disasters

In some areas, New Zealand already has enviable resilience in the face of the planet's emerging climate change challenges. Ours is a temperate climate where some of the more severe impacts of rising temperatures may be mitigated by our maritime setting in the southern oceans. However, other impacts – such as rising sea levels, and severe weather events including drought and heavy rainfall – will affect New Zealand to just as great an extent as anywhere else in the world.

For instance, most of our major cities are all vulnerable to rising sea levels, which has the potential to directly or indirectly affect the majority of New Zealand's population. At the coast, rising seas will wipe out infrastructure and threaten wildlife; if ocean water moves deeper into landmasses, the salt will contaminate sources required for drinking water and agriculture.

The first part of adaptation is to be able to measure the current and likely impacts of these changes, and the distributed sensor networks that make up the Smart Cities technology infrastructure will be key in making informed decisions about the effects of climate change. They will also be useful in helping assessing the possibility (and potential desirability) that some urban areas will see the need for relocation and potential abandonment of key infrastructure and areas prone to flooding.

While this would represent one of the largest losses of value in land and infrastructure and the largest transfer of economic wealth in New Zealand's history, it may be a necessary step in a nation with a relatively small population and long coastlines. However, tensions will grow as specific land owners and residents demand increasingly costly infrastructure hardening, while others push for less costly shifts in habitation.

The complexity of flood protection in New Orleans is an important early window on how communities will think about these issues, and having the high-quality information that can be provided by Smart Cities technologies will be an important part of having an informed public debate about when to defend an urban area, and when to retreat.

Similar debates are also possible in the face of New Zealand's demonstrated risk from earthquakes and volcanic eruptions. Both have the capacity to make sudden and large-scale impacts on the country's urban centres, with large-scale displacement, infrastructure damage and economic implications.

As the Christchurch earthquakes demonstrated, the effect on the horizontal infrastructure of the city – roads, sewerage, water, telecommunications and electricity – can be far-reaching, and in many ways as disruptive as the immediate impact on homes and offices. Having real-time information about the infrastructure would allow for greater resilience in the immediate aftermath of a major tectonic event, as well as more efficient repair and restoration of service, so Smart Cities technologies are particularly applicable to the unique challenges New Zealand faces.

## The challenge of efficiency

Whether a city is growing or declining, it is important that the infrastructure that supports it – roading, buildings, water and wastewater, telecommunications, and much more – is planned and used efficiently.

The Crown's central and local government infrastructure assets alone are worth more than a full year's total output from the economy. Collectively, central government is responsible for between $116 billion to $250 billion[3] of infrastructure assets, and local government has a further $100 billion of community assets on its balance sheets[4].

Maintaining and improving these assets requires billions of dollars of investment each year. Over the next ten years alone, approximately $110 billion is forecasted to be spent on infrastructure[5].

The Government's long-term vision for infrastructure is that New Zealand's infrastructure is resilient and coordinated and contributes to a strong economy and high living standards. Infrastructure is a key support for the way we live.

For instance, the persistent and evolving challenges around Auckland transport are very much in the public eye. Roading congestion is impeding the efficiency of Auckland

[3] This figure varies depending on how the assets are valued. The $116 billion figure came from the Thirty Year New Zealand Infrastructure Plan 2015 (Infrastructure 30-year plan) but other estimates are significantly higher.
[4] Water and roads: Funding and management challenges – Office of the Auditor General 2014
[5] Infrastructure 30-year plan

International Airport, which is a matter for concern for New Zealand businesses and for the wider economy. With tourism now New Zealand's largest export earner and tourist numbers expected to grow significantly over the next decade, having an airport that is linked to fast and efficient transport links is becoming crucial.

The need to improve asset management and performance across the state sector, as well as in the local and private sectors, was identified as a priority in the 30 Year New Zealand National Infrastructure Plan. This is partly because good management of the country's physical assets is beneficial to New Zealand's long-term fiscal position, the performance of the economy and delivering social outcomes.

In financial terms, poor investment decisions will result in a significant dead weight drag on the economy, stranded infrastructure and lower productivity than could otherwise be achieved. In social terms, poor decisions can result in reduced wellbeing.

Sound asset management is dependent on high quality decisions being made about renewing and then managing those assets over their whole life to meet demand and provide public value. These decisions will have intergenerational impacts.

Effective asset management is a virtuous cycle, as shown in the diagram:

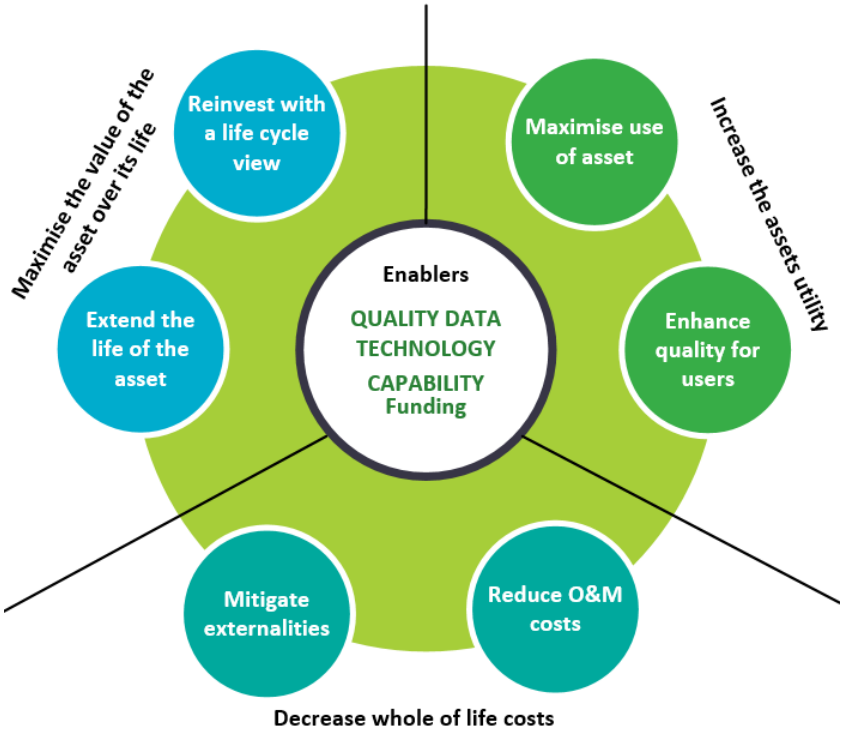



**Figure 2: Best practice asset management (adapted from a diagram from World Economic Forum[6])**

Making good decisions about asset maintenance and replacement requires high quality information. Currently, most asset replacement is projected from historical assumptions about the likely life of materials, rather than from real-time data gathered from the infrastructure itself.

[6] Strategic Infrastructure: Steps to Operate and Maintain Infrastructure Efficiently and Effectively - Prepared in collaboration with The Boston Consulting Group April 2014

However, Smart Cities technologies – such as sensor networks that can measure asset performance in real time, and advanced analytics that can make high-quality predictions about the likely lifecycle of components – can enable better decisions to be made about when to repair and when to replace. In turn, this allows every dollar of value to be extracted from existing investments.

## The challenge of affordability

Meeting the cost of infrastructure renewal and maintenance is challenging for all local authorities, especially those in areas with smaller rating and/or economic bases. This will be exacerbated in the decades ahead as regional populations decline and as more people retire from the paid workforce due to age.

Local authorities are having to respond to community calls to manage debt and reduce rate rises, and central government is focussed on returning to surplus and reducing net debt to 20 percent of GDP by 2020. This will act as a major constraint on the pool of funding available for infrastructure replacement or extension.

The challenge of asset affordability will be further increased by likely increases in national standards. For instance, the costs of meeting higher drinking water quality or wastewater treatment standards will fall on all communities, but less-populous regions will find the costs hardest to bear. This has already been seen in the Kaipara District, where long-running issues over the affordability – and cost over-runs – of a new wastewater treatment system spilled over into rates strikes, High Court action and the requirement for a validating Act of Parliament.

At the other end of the scale, larger councils face significant expenditure to meet growing populations. As has been noted, costs are highest when infrastructure is expanded at the outer boundary of a city, but even where in-fill development is used to try and limit the amount of additional infrastructure needed, the costs can still be significant. By necessity, these costs impact existing ratepayers before the additional population begins to expand the taxation base for local authorities.

Whether the drive for infrastructure investment comes from changes in community use or population dynamics, local authorities will increasingly need to demonstrate that the need is real, and that the use of existing assets has already been optimised. To do this, some of the technologies and capabilities delivered by Smart Cities will be invaluable.

## The challenge of expectations

As part of the demographic changes that are unfolding, customer expectations of service levels are increasing, which consequentially puts local and central government under pressure to increase their spending to meet these expectations.  For example:

- Stormwater services are coming under increasing public scrutiny as flooding events increase, driven by more frequent storms compounded in metropolitan areas by more paved or hard surfaces. This increases community expectations that councils will act to remedy or mitigate the issues.
- Many of the sports that have traditionally been played outdoors, such as netball, are increasingly moving indoors, driving a demand for more complex and expensive facilities. The balance between sport and recreation is also evolving –

for example, municipal pools that were originally constructed as relatively simple venues for swimming clubs need to be redeveloped as multi-use community recreational facilities, with the attendant costs and complexities.

- Regulatory standards are also increasing. Potable water standards are higher, there are greater restrictions on the flows and quality of waste water discharges, building codes have increased in the wake of major earthquakes, and the expectation from both regulators and citizens is that existing infrastructure will gradually be brought up to current standards.

For instance, the subject of how and when earthquake-prone buildings are brought up to code have been very much a matter of public debate, following the Christchurch and Kaikoura earthquakes. And territorial authorities are being challenged to provide more accurate information more quickly, so that the effects of earthquakes or other natural disasters can be gauged, and contradictory expectations managed. There is now the assumption that – following a significant earthquake – a city will be open for business again as soon as possible, but that there will be completely accurate information so that there is no residual danger to the public from damaged buildings or infrastructure.

To try and manage these expectations, both Wellington and Christchurch have commenced initiatives to add smart sensors to major buildings, so that the impact of ground movement and shaking can be assessed in near-real time. This allows more accurate investigation by engineers, so unaffected buildings can be reopened more quickly with more confidence, whilst the public can still be kept safe from damaged structures.

Irrespective of how affordable (or otherwise) increased expectations are for a local authority in a global sense, most projects are considered on a standalone basis. This means that the costs of meeting higher community standards can result in significant affordability impacts as the projects accumulate.

In this context, having better information on a range of metrics – such as asset performance, community usage and system efficiency – can play a large part in moderating requests for higher performance, as the discussion with the community can be based on objective criteria rather than assumptions or individual perception.

In addition, many of the Smart Cities technologies and approaches can be used to assist with demand management and efficient utilisation, which can deliver better performance without the need for major infrastructure investment.

## The challenge of competition

The world has seen a rapid rise in competition between cities to secure the investments, jobs, businesses and talent for economic success. Increasingly, both businesses and individuals evaluate a city's "technology quotient" in deciding where to locate.

A real challenge for cities with economies based on traditional industry is creating job opportunities that appeal to recent university graduates so they will stay and help build the kind of high-quality workforce that new and emerging industries demand.

Major cities in New Zealand are not insulated from this trend, and all have identified the need to be internationally competitive as business locations, and attractive for the pools

of highly-skilled people making up today's workforces. The role of tertiary educational institutions, business incubators and innovation parks is increasingly understood as preconditions for making a city attractive to businesses and their staff.

The ICT components of Smart Cities are obviously key building blocks, but other components – such as open data standards, efficient urban and transport infrastructure, and good environmental stewardship – all have their part to play.

In addition, Smart Cities can create their own virtuous cycles of innovation, where the possibilities of improving the city they live in prompts citizens to develop solutions and start businesses. This type of innovation is not possible unless enough Smart City infrastructure and capability exists, and the local authorities are receptive to citizen-led innovation.

## Responding to the challenges

The intersection of these challenges – growth in some areas, retrenchment in others, with cost-effective investment and management, in the face of changing community expectations and the requirement for social wellbeing and resilience – is that infrastructure must be in the right place in the right form at the right time. Achieving this outcome is no small task, and relies on being able to make good long-term decisions based on accurate data rather than anecdote.

For a nation with a relatively small population, a sometimes-challenging geography and the expectation of first-world lifestyles and outcomes, the stakes are high. The decisions made about how and where cities grow and infrastructure is deployed are by necessity long term, and as the world grows more complex, the solutions will need to be rooted in better quality information about the country and its inhabitants.

This is reflected in the Government's ambition for data-driven innovation and evidence-based policy. The impetus to share and use data to drive service delivery is recurrent across Government priorities, including the Better Public Services initiative and the Business Growth Agenda, which has six key focus areas: infrastructure, natural resources, investment, export markets, innovation, and skilled and safe work places.

While the Government has set a policy direction that is highly favourable to the development of Smart Cities in New Zealand, it is up to local authorities to implement the practical projects that will bring the vision to life. A number of responses are therefore required.

In workshops sessions with the Smart Cities Governance Group, convened by LINZ, there was consensus that both central and local government have roles to play in fostering the right outcomes. The summary of the Governance Group is that:

> Central government needs to:
>
> - Provide an effective principles-based legislative framework for privacy to overcome the risk aversion of citizens and commercial providers alike, with the intention of achieving social license for the key elements of Smart Cities
> - Help foster public engagement and a consensus that smart cities are a valid response to the emerging challenges faced in a range of

- Promote the adoption of standards for interoperability to minimise the risk of stranded investments or poor-quality outcomes
- Acknowledge and foster innovation and knowledge sharing (via local government) for NZ's wider benefit
- Fostering commercial innovation built on top of the shared smart cities infrastructure as part of the Business Growth Agenda

Local government needs to:

- Build on the national policy direction for Smart Cities, by aligning local strategies and planning objectives through their Long Term Plans and relevant strategy documents
- Build partnerships with technology companies, service providers and innovators to develop the Smart City solutions that are relevant for their communities and specific challenges
- Commit to the open sharing of Smart Cities data and interfaces, whilst observing the principles of the Privacy Act and other relevant legislation
- Invest in and deploy the solutions that will benefit their communities, initially in pilot form and then as part of the infrastructure of the city once their value and effectiveness has been proven
- Openly share their experiences and results with central government and other local authorities, so lessons can be learned and capability developed throughout the country

These responses will require an ongoing collaborative dialogue between central government, local authorities and the private sector. However, there is every reason to think this will be a successful model in New Zealand, given the effective collaboration that has occurred as a result of the seed funding from the Better Public Service initiative, which has resulted in high-quality Smart City implementations throughout the country.

## Developing trends in technology

There are a number of developed and emerging technologies that are allowing information to be captured, collated and analysed for better decision making. Some of these technologies make up the key building blocks for Smart Cities, such as:

1. The development of low-cost low-powered system on a chip (SOC) processors, that are cheap enough and ubiquitous enough to be able to be deployed as part of cost-effective sensor networks.
2. Sensors can be linked using wireless mesh networks, which have fallen in cost and power consumption to the point where they can be robustly deployed in crowded urban environments and across relatively wide geographical areas.
3. Cloud-based processing allows data to be collated from a wide range of disparate sensors and networks in a way that is cost-effective and available to a wide range of users and technical interfaces, providing an open platform on which applications and solutions can be developed
4. Big data analytics and effective data science allows insights to be obtained that were previously unobtainable from local analysis, using powerful statistical tools and predictive algorithms.

Forrester Research describe this intersection of capabilities as Smart Computing:

A new generation of integrated hardware, software, and network technologies that provide IT systems with real-time awareness of the real world and advanced analytics to help people make more intelligent decisions about alternatives and actions that will optimise business processes and business balance sheet results.

Not all emerging technologies are contributors to Smart Cities, but a number of them will play a part in making realising the vision. And every year, Gartner releases its hype cycle that provides a useful overview of emerging technologies and their likely adoption rates. In the words of Mike J. Walker, research director at Gartner, the hype cycle is make up of "the set of technologies that is showing promise in delivering a high degree of competitive advantage over the next five to 10 years".


Source: Gartner (July 2016)

Some key hype cycle technologies that are likely to be relevant to the Smart Cities of the next few decades are:

- **802.11ax** – This is the next evolution of the Wi-Fi standard, which will improve the performance of Wi-Fi-enabled devices and support a larger number of them. Development of this technology is still in early stages according to Gartner, but expect it to be important as the number of connected "Internet of Things" devices continues to grow.
- **IoT platform** – The Internet of Things platform is a suite of components that enable the deployment of applications that monitor, manage, and control connected devices, that provide remote data collection from connected devices, and independent and secure connectivity between devices. It is typically provided as a cloud-based service so that it can integrate with any connected device and blend in with device applications, without the need for large-scale ICT deployments.

- **Data Broker PaaS (dbrPaaS)** – A Data Broker is a business that aggregates information from a variety of sources; processes it to enrich, cleanse or analyze it; and licenses it to other organizations. Data brokers can license another company's data directly, or process another organization's data to provide them with enhanced results. Data is typically accessed via an application programming interface (API), and frequently involves subscription type contracts. A dbrPaaS typically provides this complex functionality as a cloud-based service.
- **Smart Dust** – This refers to little things called "motes," which Gartner defines in a research note for the report as "tiny wireless micro-electromechanical systems (MEMS), robots, or other devices that can detect everything from light, temperature, and pressure to vibration, magnetism, and chemical composition." CNN put it this way in 2010: Smart dust aims to monitor everything.

Gartner puts the large-scale adoption of most of these technologies in the 5 to 10 year timeframe, and – assuming they are able to be successfully commercialised – they will provide additional building blocks, capabilities and services that will augment the Smart Cities components that are available today.

As can be seen from Gartner's analysis, the key trends are:

1. The range of sensors will grow; they will become smaller and more ubiquitous; and the wireless networks that enable them to communicate will grow in sophistication, meaning that it will become affordable and feasible to apply instrumentation everywhere
2. Our ability to make sense of and use the increasing floods of data from sensors will develop in both extent and sophistication. The breadth and depth of data will grow dramatically, which will enable insights that were previously not apparent
3. Many of the key components of Smart Cities – from the Internet of Things to data science – will begin being offered as platforms and services, so that the cost of participation decreases and smaller entities can participate on an equal footing to their larger brethren.

In effect, these global technology trends will allow local authorities in New Zealand to begin participating in the Smart Cities revolution in a way that is cost-effective for ratepayers whilst delivering significant benefit to their communities.

In addition to the evolving technical capabilities, the growing understanding from decision-makers of the power of information allows the best decisions to be made at the right time for both infrastructure investment and better operational outcomes – which is a key objective of any Smart Cities initiative.

## How technology can be applied to smart cities

Building on the Forrester Research idea of Smart Computing, the Smart Cities Council describes how technology is used to turn communities into smart cities:

> A smart city uses information and communications technology (ICT) to enhance its liveability, workability and sustainability. In simplest terms, there are three parts to that job: collecting, communicating and analysing. First, a smart city collects information about itself through sensors, other devices and existing systems. Next, it communicates that data using wired or wireless networks.

> Third, it analyses that data to understand what's happening now and what's likely to happen next.

Trevor Dorling, director of Digital Greenwich, the council's in-house smart city programme, is sceptical of companies that pitch automation technologies as a means of cutting staff. "I don't think that's our starting point at all," he says. "We want to embrace technology and improve services, and try to square the circle of increasing demand at a time of severe cuts in public funding.

"The population of Greenwich is growing rapidly," Dorling adds. "That places tremendous pressures on infrastructure and services, and there's no longer the money to solve those problems in the way they've traditionally been solved.

The data collected by smart cities can be used to optimise the performance of a myriad of systems, and then make predictions about what will happen next. The behaviour of traffic flows, potential flood events, likely earthquake performance, population changes and many of the other challenges that are faced by today's cities can be modelled and assessed, and the right operational and policy decisions made about effective responses.

This thinking is reflected in the Government's ICT strategy where better use of information to drive insights and reshape services and policies is one of the outcomes sought. Similarly, good quality data is required to accelerate the adoption of information and technology innovations.

# Current state

## Smart Cities

There are as many definitions of what comprises a Smart City as there are participants in the process of building them. However, Wikipedia defines Smart Cities in the following way:

> Smart Cities can be identified (and ranked) along six main axes or dimensions. These axes are: a smart **economy**; smart **mobility**; a smart **environment**; smart **people**; smart **living**; and, finally, smart **governance**. These six axes connect with traditional regional and neoclassical theories of urban growth and development. In particular, the axes are based – respectively – on theories of regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and participation of citizens in the governance of cities.
>
> A city can be defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory governance.

In this context, the definition of city is pertinent. Many commentators and subsequent projects have emphasised the fact that smart city technology, approaches and

governance methods can be applied at a variety of scales. Smart Cities projects have included entire urban areas, specific neighbourhoods and defined areas such as University campuses or business parks. All are relevant to both the development and deployment of Smart Cities technologies.

The Smart Cities Council defines a smart city as one that "uses information and communications technology (ICT) to enhance its liveability, workability and sustainability."

Deakin and Al Wear list four factors that contribute to the definition of a smart city:

1. The application of a wide range of electronic and digital technologies to communities and cities
2. The use of ICT to transform life and working environments within the region
3. The embedding of such ICTs in government systems
4. The territorialisation of practices that brings ICTs and people together to enhance the innovation and knowledge that they offer.

Deakin defines the smart city as one that utilises ICT to meet the demands of the market (the citizens of the city), and that community involvement in the process is necessary for a smart city.

## Activity in New Zealand

In 2015 LINZ received Better Public Services funding from Treasury to work alongside three city councils on pilot projects to help the councils build a better understanding of how cities operate, and inform decisions about the possible implementation of sensing technologies in New Zealand.

One of the reasons for deciding to work collaboratively with local government is that councils have similar types of assets to central government; however, the scale is smaller and many local authorities are more nimble given the decisions they make impacting a smaller number of people and geographic area. Councils can therefore test Smart Cities approaches and technologies in a way that might be cost-prohibitive to trial on a national scale. The learnings from these experiments and pilots can then be applied to other areas across the country.

In order to co-develop Smart Cities approaches in New Zealand, LINZ are currently working with Auckland, Wellington, and Christchurch city councils, co-funding a range of initiatives from counting traffic and pedestrian movements to monitoring city air and water quality.

These are proof of concept projects, seeking evidence that the initiatives:

- Have been developed in a way that allows other cities to use them
- Have the potential to create significant social benefits.

Together with Auckland, Wellington and Christchurch councils, LINZ has identified key benefits that are being sought from the proof of concept projects:

- Access to more data that will help central and local government form new policies, and improve planning and decision-making at a local, regional and national level
- More resilience in how the country plans for, manages and funds city assets through improved maintenance planning, and better understanding of how these assets can be used
- Attraction of international talent to experiment and develop technologies in New Zealand cities as 'living laboratories'
- Creation of new business opportunities, employment and export earning through supporting existing and start-up companies to use sensor technologies and data services.

While the initial funding is set to expire at the end of 2016, it is anticipated that both the pilot projects and the learnings from them will continue into the future, and become part of the Smart Cities infrastructure in New Zealand.

# Smart Cities in action

## Case Study 1: Queenstown Lakes District Council

As one of New Zealand's most desirable destinations, Queenstown Lakes District is continually experiencing significant employment, visitor and population growth. This has led to increasing pressure on the council to manage the associated infrastructure and environmental demands.

To better understand – and ultimately improve – how the district manages this growth QLDC are using 3D GIS technology as a key decision making tool. By visualizing complex features, 3D GIS has enabled QLDC to model District Plan rules such as maximum and minimum building heights to rapidly generate their built and natural environment.

Modelling proposed buildings in 3D web scenes and developing public feedback surveys has provided a better understanding of their planned developments and the social impacts this could have on the Queenstown community. By combining 3D technology with existing geographic information the council had available, QLDC have opened numerous opportunities to enhance life in the district.

As Ryan Clements, CIO of the Queenstown District Lakes Council noted:

> "Council staff at every level, junior officer to Chief Executive, are making decisions every day. 3D GIS is being used as an effective tool for understanding, engagement and insight and is in turn supporting better decision making.

## Case Study 2: Palmerston North City Council

Fly tipping is on the rise, in Palmerston North and across the county. Using Smart City technology, PNCC are providing their city with a new platform of engagement through mobile apps, dashboarding and real time data visualization.

The city has taken a map driven approach to this issue, by collating data on fly tipping and visualize live incidents with a series of web maps. These maps have then been used to drive the dispatch of work crews to attend to incidents, collect evidence/data and in some cases take offenders to court. Providing live statistics and mapped visualizations

on the problem has helped the council make informed decisions and respond to incidents in real time, as well as identify financial implications and geographic hotspots.

On the technical side this has included workers being digitally directed to organized lists of fly tipping incidents. The project has used cloud computing and storage using Android & IOS devices along with ESRI's Survey123 app, Operations Dashboard, Workforce and ArcGIS Pro. The improved efficiency in data capture and incident response from this project will inform future decisions and one day make fly tipping a thing of the past in Palmerston North.

Lucas Mostyn, GIS Analyst Programmer for Palmerston North City Council said:

> Having live data and especially pictures of the problem so easily available has made a real difference. When this was just on paper no one cared, now that everybody can see the scale and detail of the issue it's getting so much more support.

## New Zealand as international laboratory

New Zealand is a somewhat unique nation, in that it is a small and innovative first-world country that has a long history of early technology adoption.

For instance, in the 1980s and 1990s multinational consumer electronics firms would routinely test-market new devices such as video cassette recorders in New Zealand before introducing them internationally. They discovered that our market was a good proxy for the wider Organisation for Economic Co-operation and Development (OECD), and that products and services that succeeded in New Zealand were likely to do well in larger international markets; conversely, products that failed here were also likely to fail internationally.

The same is also true of Smart Cities technologies. Both the early-adopter nature of our culture and the relatively small size of our urban centres – combined with largely first-world infrastructure – means that New Zealand is an attractive place to test key components of Smart City solutions.

There have been several examples of this already. NEC has worked extensively with the Wellington and Christchurch city councils to implement its world-leading KITE technology, primarily fostered by the passion of the councils and the receptiveness of senior NEC executives.

Following initial contact between council and NEC staff, the Wellington mayor visited senior NEC executives in Japan, which provided a foundation for the development of a Memorandum of Understanding (MOU). In turn, this led to a deepening collaboration, with NEC working proactively on solutions to address Wellington's unique needs.

In some cases, the council was its own guinea pig, implementing technology within its own buildings and sites in order for both the council and NEC to understand how best to apply it in the wider city. The relationship has then grown and deepened as the technology is applied to more use cases in Wellington, to the benefit of both organisations.

These prototype and laboratory-style implementations carry significant benefit for New Zealand, such as a level of assistance from and interaction with international technology vendors that would not be the case if we were simply purchasing products. In turn, this allows solutions to be customised for New Zealand conditions.

The New Zealand government has made explicit commitments to strengthening our digital economy through participation in the Digital 5 network of leading digital governments.

The D5 network members are bonded by the principle of openness; they are focused on changing government's relationship with technology by adopting open standards and open-source software as well as making digital government more effective. They intend to bring in digital skills in-house and encourage short-term contracts with small and medium business suppliers.

Along with the other participating nations – Estonia, Israel, South Korea and the United Kingdom – New Zealand signed a charter in 2014 committing to share and improve upon the participant nations' practices in digital services and digital economies. In the agreement, they stated that their collective goal is to "harness the potential global power of digital technology and help each Participant to become an even better digital government faster and more efficiently through sharing and learning from each other."

The initial D5 targets are:

- User needs – public services for citizens
- Open standards – a commitment to royalty free open standards
- Open source – Government systems, tradecraft and manuals will in the future be open source and shareable between members
- Open markets – support for startups and equal competition despite company size
- Open government – transparent and open licenses and data
- Connectivity – build and maintain high quality digital infrastructure that supports the digital population
- Teach children to code – provide children with the skills needed to become the next generation of coders
- Assisted digital – support all citizens so that they can access digital services
- Commitment to share and learn – members share and work together to meet set goals

This commitment to technological openness and collaborative development helps make New Zealand an attractive partner for the private sector. While this is useful and our commitment to the digital economy is proven, more work can be done to ensure that additional researchers and vendors will engage with New Zealand. Potential actions include:

- Maintaining and promoting international linkages to relevant organisations and countries, through initiatives such as attending and hosting international Smart Cities conferences
- Hosting international city and vendor delegations to showcase the initiatives that have been implemented in New Zealand and to discuss future opportunities
- Participating in the development of Smart Cities international standards, such as those convened by the Open Geospatial Consortium

- Maintaining a focus on communicating the successes and challenges of Smart Cities in New Zealand, so that both local and international vendors can see the opportunities presented by collaborating with local and national government.

# The desired future state

A Smart City (also community, business cluster, urban agglomeration or region) uses information technologies to:

- Make more efficient use of physical infrastructure (roads, built environment and other physical assets) through artificial intelligence and data analytics to support strong and healthy economic, social, cultural and environmental development
- Engage effectively with local people in local governance and decision by use of open innovation processes and e-participation, improving the collective intelligence of the city's institutions through e-governance, citizen participation and co-design
- Learn, adapt and innovate and thereby respond more effectively and promptly to changing circumstances by improving the intelligence of the city.

Over time, Smart Cities evolve towards a strong integration of human intelligence, collective intelligence and machine intelligence within the city. The intelligence of cities "resides in the increasingly effective combination of digital telecommunication networks (the nerves), ubiquitously embedded intelligence (the brains), sensors and tags (the sensory organs), and software (the knowledge and cognitive competence)".

These forms of intelligence in smart cities have been demonstrated in three ways:

- **Orchestration intelligence**: Where cities establish institutions and community-based problem solving and collaborations, such as in Bletchley Park, where the Nazi Enigma cypher was decoded by a team led by Alan Turing. This has been referred to as the first example of a smart city or an intelligent community.
- **Empowerment intelligence**: Cities provide open platforms, experimental facilities and smart city infrastructure in order to cluster innovation in certain districts. These are seen in the Kista Science City in Stockholm and the Cyberport Zone in Hong Kong. Similar facilities have also been established in Melbourne.
- **Instrumentation intelligence**: Where city infrastructure is made smart through real-time data collection, with analysis and predictive modelling across city districts. There is much controversy surrounding this, particularly with regards to surveillance issues in smart cities.

The city of the future should be:

- Responsive to the needs of its citizens
- Environmentally sustainable
- Efficient in the use of resources
- Cost-effective to operate
- Flexible in the way it responds to changing needs and external pressures

The technology that enables Smart Cities should be:

- Open and interoperable



- Secure
- Observe the principles enshrined in the Privacy Act
- Extensible and future-proofed

Participation in the development of Smart Cities should be:

- Open to both public agencies (local, regional and central) and the private sector
- Engage all citizens in both the development of Smart Cities and the sharing of the resulting knowledge
- Respectful of the full range of cultures, races and identities of citizens

In practical terms, the difference between the current ways cities operate and how they function as Smart Cities can be shown as follows:

| | The Problem | The Smart City Solution |
|---|---|---|
| Planning | • Ad hoc and decentralized<br>• Cost savings aren't realized<br>• Limited potential for scalability of investment | • Coordinated and holistic Resources are shared<br>• Cost savings are fully realized Investments are scalable<br>• Improved city planning and forecasting |
| Infrastructure | • Runs inefficiently<br>• Costs more money and resources to run | • Optimized with cutting-edge technology<br>• Saves money and resources<br>• Improved service-level agreements<br>• Built on open standards |
| System operators | • Guess at infrastructure conditions<br>• React to problems<br>• Can't deploy resources efficiently to address problems | • Enjoy real-time reporting on infrastructure conditions<br>• Predict and prevent problems<br>• Deploy resources more efficiently<br>• Automate maintenance<br>• Save money |
| ICT investments | • Piecemeal and siloed<br>• Deliver suboptimal benefit<br>• Don't realize economies of scale | • Centrally planned<br>• Deployed across city departments and projects<br>• Deliver optimal benefit<br>• Provide maximum value and savings |
| Citizen engagement | • Limited, scattered online connection to citizens<br>• Citizens can't make optimal use of city services (or easily find them) | • Complete and singular online presence<br>• Citizens can easily find and use services<br>• Citizens can participate in smart city initiatives<br>• Two-way communications between government and people<br>• Specialized services focused on the individual citizen |

| | The Problem | The Smart City Solution |
|---|---|---|
| | | • Citizens can both contribute to and access real-time intelligent city data and offer apps that use the data |
| Sharing data | • Departments and functions are siloed<br>• Departments rarely share data and collaborate on initiatives | • Departments and functions are integrated and/or shared<br>• Data is shared between departments and better correlated with other data services through open standards<br>• Results are improved<br>• Costs are cut |

The work undertaken to date within New Zealand has highlighted key factors that are needed for Smart Cities initiatives to succeed:

- **Leadership is critical**. Having both political and management support of Smart Cities initiatives is a necessary precursor, particularly when specific initiatives are implemented on a pilot basis. Some initiatives may not succeed or may need radical alteration to fit the needs of the city, so having support from both governance and management teams will be key in moving from good idea to robust implementation.
- **Identify problems where technology enables solutions**, rather than just adopting technology for its own sake. This is crucial in ensuring the solutions are relevant to the needs of citizens and will deliver their investment goals.
- **Be consistent in the way Smart Cities are approached**. Having open data standards and active collaboration between the public and private sectors will enable a Smart Cities ecosystem to develop, and for better solutions to be developed more quickly.
- **Accept quick successes and fast failures**. Not all initiatives will result in production-ready solutions, so there needs to be an acceptance that some ideas will not work in the local environment, even if they have been successful elsewhere in the country. Adaptability and flexibility are key to achieving sustainable results.

# The importance of taking action

The ability for communities and governments to develop Smart Cities is occurring because of the confluence of several factors:

- The cost of smart sensors and wireless mesh networks has fallen to the point where it is cost-effective to deploy large numbers of sensors at the scales necessary to monitor and measure a metropolitan area
- The power and ubiquity of cloud computing has made it feasible to aggregate, integrate and distribute the resulting data without the need to invest in large-scale IT platforms
- The development of effective big data management techniques and data science approaches is allowing useful insights to be gathered, and higher-quality

decisions made on both day-to-day operational matters and long-term investments

These are the push factors associated with Smart Cities; in themselves, they are merely the enablers, and while they are an essential building block of Smart City capability, they do not guarantee that the technologies will be adopted or that the benefits will be achieved.

The primary pull factor is the developing challenge of demographics – an aging population, high levels of immigration, rising expectations from citizens, a long-term trend to urbanisation, and the need to address the challenges of climate change. Whether an urban centre is expanding or contracting in response to these pressures, there is a strong incentive to make better use of infrastructure and be efficient and responsive in the way services are delivered to communities.

New Zealand has committed itself to embracing the digital revolution, through the intergovernmental D5 network, and this – along with major policy directions such as the Business Growth Agenda – has provided the national platform for the development of Smart Cities. In turn, local government has begun the process of piloting and deploying solutions that will benefit their communities, thus beginning the process of turning Smart Cities from a concept into an essential part of New Zealand's urban fabric.

While the work done to date has been innovative and effective, it's clear that both the "push" factors and the "pull" factors are gathering momentum. The demographic, economic and environmental issues that are challenging cities are becoming more urgent with each year, and the accelerating rate of technological change is opening up new possibilities in how local authorities can respond.

Cities must adapt and respond to the changes that will gradually engulf them in the coming decades – and that for the first time, the technological capability exists to do so, and to re-make cities in a new way in the process. The challenge is to respond with effective solutions before the demographic and environmental issues become intractable, or prohibitively expensive to solve.

# Investment objectives

From a national strategic perspective, the intention of investment in Smart Cities is to achieve a range of economic, efficiency, environmental and social outcomes:

**Social outcomes**

- Improved citizen wellbeing and social cohesion
- Improved societal outcomes in areas such as public safety, health and education

**Efficiency outcomes**

- Better operational management of cities and their infrastructure
- Improved investment efficiency and predictability for key infrastructure assets

**Environmental outcomes**

- Reduced environmental impact from urbanisation and natural events

- Better long-term environmental management and stewardship

**Economic outcomes**

- The development of Smart Cities knowledge and capabilities by participants
- Increased innovation in Smart Cities approaches and technologies
- Improved export performance from companies specialising in Smart Cities

The benefits from these outcomes accrue in different ways to different parts of society; individuals, the communities they belong to and the companies and organisations that either contribute to or consume information generated by Smart Cities. The relative benefits can be shown as follows:

| | Individuals | Communities | Organisations |
|---|---|---|---|
| Social outcomes | Strongly contributes | Strongly contributes | Somewhat contributes |
| Efficiency outcomes | Somewhat contributes | Strongly contributes | Somewhat contributes |
| Environmental outcomes | Strongly contributes | Strongly contributes | Strongly contributes |
| Economic outcomes | Somewhat contributes | Somewhat contributes | Strongly contributes |

From this analysis, the primary investment objectives for Smart Cities are:

1. To provide improved social wellbeing and enhanced community cohesion for citizens
2. To enable local authorities to deliver improved services to their communities at lower cost and at greater efficiency, with improved flexibility
3. To tangibly improve the environmental stewardship outcomes for urban centres and mitigate the effects from climate change and adverse natural events
4. To provide an open technology and information platform within which citizens, local authorities and businesses can interoperate and collaborate, which is compliant with the principles in the Privacy Act

*Note for business case writers: guidance on making the investment objectives SMART (specific, measurable, achievable, realistic and time-bound is contained in the How-To Guide attached to this document.*

# Investment scope

## In scope

The following items are in scope for this business case:

1. The further development of Smart Cities in New Zealand

2. Development of the tools and technologies necessary to progress Smart Cities in New Zealand
3. Development of the knowledge and skills in individuals, communities and organisations necessary to foster the development of Smart Cities in New Zealand

## Out of scope

The following items are out of scope for this business case:

1. Direct Research and Development into the technology components that enable Smart Cities
2. Direct investment in organisations or businesses servicing the Smart Cities market in New Zealand or overseas
3. Investment in the technical or interoperability standards necessary for Smart Cities
4. Investment in establishing data standards or addressing data quality issues that support Smart Cities

# Strategic alignment

The key points of legislative and strategic alignment are:

### The Government's Business Growth Agenda

Building a more competitive and productive economy for New Zealand is one of the key priorities the Prime Minister has laid out for this Government to achieve. The Business Growth Agenda (BGA) is the central strategy that articulates this vision, by focusing on the key drivers for improving business confidence and further investment.

The Business Growth Agenda is a multi-decade strategy aimed at building a more competitive and productive economy for New Zealand, and identifies six key inputs that businesses need to succeed and grow, as shown in the diagram below:


*Source: Ministry of Business, Innovation and Employment*

There are six areas of focus in the Business Agenda:

1. Building Export Markets
2. Building Innovation
3. Building Investment
4. Building Natural Resources
5. Building Skilled and Safe Workplaces
6. Building Infrastructure

Of these, Smart City solutions are strongly aligned with objectives 1, 2, 3 and 6.

## Land Information New Zealand's strategic objectives

The role of LINZ is to make sure New Zealand has:

- a world-class location system
- accurate location information
- robust property rights
- sustainably managed Crown property

The Agency works across land, sea, data, crown property and regulatory areas to:

1. **Increase the use of geographic information** - We will drive the delivery of accessible and usable geographic information for industry and government to provoke better decisions and inspire innovation.
2. **Unlock the value of property -** We will target New Zealand's property services and information so that people making decisions on Crown land, Māori land, and urban intensive areas can realise its potential.
3. **Improve resilience to natural events** - We will enable those who are making decisions on the impacts and risks of natural hazards to have the right information that will help protect New Zealanders and their assets.

Of these, Smart City solutions are strongly aligned with objectives 1 and 3.

## The Local Government Act 2002

The Local Government Act 2002 sets the regulatory framework for territorial authorities in New Zealand, and provides a mechanism for communities to plan their environments via the Long Term Plans of councils. Under the legislation, the purpose of local government is:

- To enable democratic local decision-making and action by, and on behalf of, communities; and
- To meet the current and future needs of communities for good-quality local infrastructure, local public services, and performance of regulatory functions in a way that is most cost-effective for households and businesses.

Under the Act, *good-quality*, in relation to local infrastructure, local public services, and performance of regulatory functions, means infrastructure, services, and performance that are:

- efficient; and

- effective; and
- appropriate to present and anticipated future circumstances.

It is apparent that all of the objectives of the Local Government Act 2002 are strongly aligned with the investment goals of Smart Cities.

# Investment risks

There are a range of risks associated with investments in Smart Cities. To some degree, the specific risks will depend on the nature and intent of the specific investment being contemplated; however, the categories of risk are likely to be consistent across a range of Smart Cities initiatives. The categories are:

## Solution risks

Solution risks arise when the potential solution is not well-matched to the desired outcomes. This typically occurs when the solution is technology-driven rather than being anchored in the requirements of cities and their communities.

Solution risks can include an incorrect scope that leads to a design that is not fit for purpose; incorrect configuration leading to designs that are not fully suitable for a city's needs; or unexpected changes the detailed design and implementation process, leading to a sub-optimal outcome.

## Implementation risks

Implementation risks describe the challenges that may occur during the implementation phase for the initiatives described in the business case

Implementation risks can include cost over-runs in the project, leading to the requirement for additional funding and a lower return on investment than has been forecast; or there may be slippage in the project leading to potentially higher costs, the requirement for additional funding and a lower return on investment than has been forecast

## Operational risks

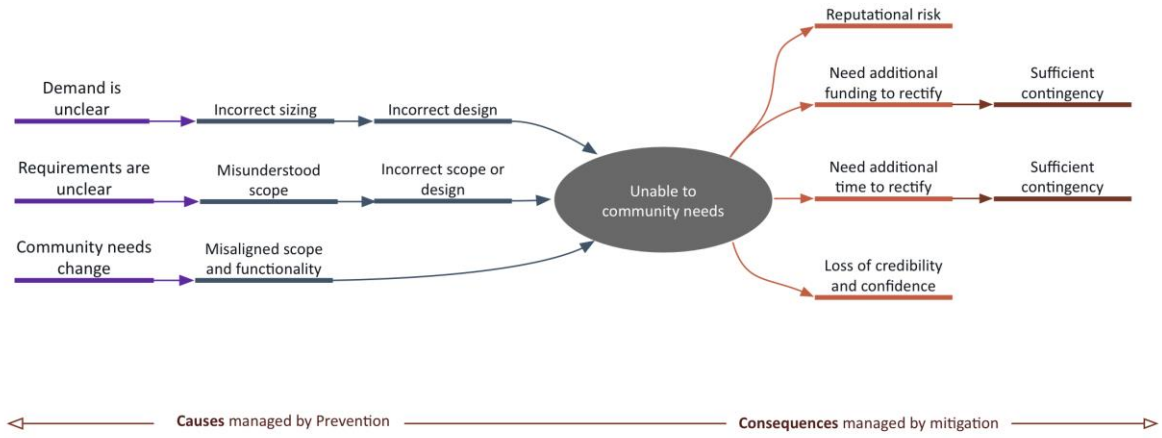
Operational risks describe the challenges that may arise once the solutions in the business case have been implemented and have been handed over to day-to-day operational management.

Operational risks may include changes to the economic, environmental or societal circumstances for the city, meaning that the expected community outcomes cannot be achieved; there may be insufficient usage by citizens or territorial authorities than has been forecast, leading to lower utilisation than has been predicted; or the costs of operating the solution may be higher than forecast, leading to higher subsidies being required and undermining the projected return on investment.

## Benefit realisation risks

In comparison with the relatively straightforward risks associated with delivery of the Smart Cities investments, the outcome risks are significantly more complex to manage. This is because they identify the challenges around ensuring the outcomes desired by cities and communities are delivered as a result of the investment.

The nature of the risks means that it is difficult to quantify either the probability or the likelihood with any degree of rigor, as there are a significant number of interlinked challenges and interventions. In accordance with more advanced risk management methodologies, the outcome risks will need to be assessed using a bowtie analysis, an example of which is shown as follows:




Detailed analysis of the risk bowtie is conducted in the relevant section of the Economic Case later in the business case.

> *Note for business case writers: additional material regarding risk analysis is available in the How-To Guide attached to this document.*

# Investment constraints and dependencies

## Constraints

There are a number of constraints that apply to the development of Smart Cities, as follows:

1. There is no specific central government funding available for specific Smart Cities initiatives, so each business case needs to stand or fall on its merits.
2. Development of a national metadata standard for infrastructure is underway, led by LINZ. This will have implications for how some infrastructure – such as the three waters, roading and public buildings – is described, so proposed Smart Cities initiatives will need to be cognisant of the standard and its implications.

3. The Privacy Act provides a set of legislative principles that must be observed by any Smart Cities initiative.

## Dependencies

The standards developed as part of the national infrastructure metadata programme are likely to be dependencies for some Smart Cities investments.

# Conclusions from the Strategic Assessment

Thanks to the confluence of a range of current and emerging ICT technologies and their falling costs, Smart Cities have recently become feasible for local authorities to develop and deploy in New Zealand. These technologies have the potential to produce significant societal, efficiency, environmental and economic benefits for both territorial authorities and their communities.

Wider benefits are also felt by central government and businesses, due to the improved opportunities for improved citizen participation, better economic prospects for individuals and communities, and opportunities for NZ Inc to be part of important global technology developments.

The capabilities of Smart Cities are necessary to address New Zealand's emerging 21st Century requirement to grow the right cities in the right way. Urban centres are being challenged by the need to adapt to global demographic changes, rising levels of urbanisation, the need to be resilient in the face of a changing climate and more severe weather events, the need for economic competitiveness, and the evolving expectations of citizens.

In order to respond to these pressures, the infrastructure that cities depend on must be flexible, adaptable, efficient, and able to be cost-effectively managed and maintained. Gathering real-time data through distributed sensor networks and then acting on the information using open cloud-based systems will allow territorial authorities to make timely high-quality operational decisions, as well as better investment choices in the future.

The development of Smart Cities is strongly aligned with both central and local government strategic directions. The risks of implementing specific Smart City technologies in urban centres in New Zealand are manageable, and the potential benefits are significant.