GLOBAL URBAN INNOVATION BRIEF

No. 3

DiSTEP Daejeon Institute of Science & Technology for Enterprise & People

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Foreword

The Daejeon Institute of Science and Technology for Enterprise & People (DiSTEP) continues to advance policies that strengthen the region's innovation capacity and foster new industries grounded in science and technology. Building on this foundation, the City of Daejeon has positioned ABCD+QR—Aerospace, Biohealth, Chips (Semiconductors), Defense, Quantum, and Robotics—as its core strategic sectors and is accelerating efforts to enhance its global competitiveness.

The 2025 Global City Innovation Brief explores how leading cities around the world are addressing complex urban challenges through scientific and technological innovation. This edition features cities pioneering nature-based climate strategies, places that are modernizing public services such as mobility, healthcare, and governance through digital transformation, and regions cultivating new engines of growth by strengthening innovation ecosystems and industrial capabilities. It also highlights cities that have advanced inclusive development through collaborative governance and active civic engagement.

Although each city's context and priorities differ, a clear pattern emerges: global cities are shaping sustainable development models by integrating technology, data, and strategic industry planning. This shared direction resonates strongly with Daejeon's own vision for the future and offers valuable insights for shaping and implementing regional innovation policy.

DiSTEP will continue expanding international knowledge-exchange networks and deepening cooperation with global cities. We remain committed to supporting Daejeon's evolution into a global innovation hub powered by science and technology.

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Lowell, USA

Collaborative Innovation Accelerates Sustainable Urban Transformation in Lowell, Massachusetts

Applying the Quadruple Helix Model to America's First UN-Habitat Frontrunner City

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Abstract

Lowell is an emerging success story of sustainable urban transformation achieved through collaborative innovation and inclusive governance. A pioneer of America's industrial revolution, Lowell has redefined its growth by enabling successful integration of government, academia, industry, and civil society, with the principles of collaborative governance. It has been recognized as the first United States city designated a UN-Habitat "Frontrunner City". In this case study, we examine the mechanisms that helped Lowell align its policies and projects primarily with Sustainable Development Goal 11 (SDG 11). The Lowell model highlights how leadership commitment, stakeholder participation, and institutional learning have fostered resilience and inclusiveness while accelerating innovation. It offers strong implications for ways mid-sized post-industrial cities can leverage historical resources, civic partnerships, and data transparency to achieve sustainability goals.

Keywords **Sustainable Urban Transformation, Quadruple Helix, Collaborative Governance, UN Habitat Frontrunner City, Lowell**

Historical Context and Urban Transformation of Lowell

Few cities in New England embody both the promise and turbulence of industrial urbanization as vividly as Lowell, Massachusetts. It was founded around the 1820s along the Merrimack River. As America's first planned industrial city, Lowell became an experiment in harnessing waterpower for textile production and a new model of urban growth. An elaborate canal system helped transform the natural flow of water into mechanical energy, spawning mills that were later known as the "Lowell system" of industrial efficiency, labor discipline, worker education, and civic order (Dublin, 1993). The waterways also framed a distinctive urban landscape where infrastructure, labor, and community co-evolved. However, manufacturing declined after the mid-twentieth century, weakening Lowell's economic base and civic identity. The city faced the typical post-industrial challenges of declining incomes, job losses, and educational disparities.

Over the past decades, despite its demographic and economic challenges, Lowell has emerged as a model for small-city reinvention based on heritage preservation, education, and cultural tourism (Gittell & Wilder, 1999). The river feeding the mills has now become a source of renewal for an inclusive suburban life. It now supports environmental restoration, recreation, and innovation corridors that form Lowell's twenty-first-century identity as a sustainable, knowledge-based city and innovation hub. Lowell National Historical Park attracts more than 500,000 visitors annually and serves as a "living laboratory for adaptive reuse, canal restoration, and cultural-economy initiatives" (National Park Service, 2024).

Lowell's population is approximately 116,000 in 2024 including 40 national origins (U.S. Census Bureau, 2024). The median household income is about $73,000, and roughly one in four residents holds a bachelor's degree or higher. The city's economics has gravitated more toward education, health care, advanced manufacturing,

Figure 1. An aerial view of the city of Lowell, MA in 1937
(Source: Wikipedia)

and clean energy, driven mainly by the University of Massachusetts Lowell (UML) and regional health institutions such as Lowell General Hospital. Several neighborhoods continue to experience housing-cost burdens and poverty even though unemployment remains close to the Massachusetts average (3 to 3.5 percent). It is not surprising that these socioeconomic disparities continue to dominate the city's sustainability and equity agenda. Crime indicators, once among the highest in the region, have declined markedly in recent years (Lowell Police Department, 2024). Public safety, which constrained investment for many years, has now become a foundation for inclusive and resilient urban growth.

Lowell's stakeholders, including city leaders, businesses, academic institutions, and community organizations,

Figure 2. Lowell downtown and canals adjacent to the mills in 2000's (Source: Wikipedia)

have successfully collaborated to overcome their major urban challenges since the early 2000s. They have planned and initiated major redevelopment projects to address these issues with a parallel focus on aligning the transformation with the UN SDGs. As a result, Lowell has rebuilt its twenty-first-century identity as a sustainable and knowledge-based city.

In 2025, Lowell was recognized as the first United States city to be designated as a "Frontrunner City" by the Urban Economy Forum, in partnership with UN-Habitat, the World Urban Pavilion, and the United Nations University Institute for Water, Environment and Health (UNU-INWEH). The designation recognizes cities making measurable progress toward SDG 11, which involves making cities inclusive, safe, resilient, and sustainable. The City of Lowell's delegation highlighted the city's transformation through data-driven governance, citizen participation, and equitable urban planning during the United Nations celebrations in Geneva (City of Lowell, 2025).

Lowell's recent urban transformation and recognition stem from numerous successful initiatives developed and implemented over the past decade. Table 1 provides a chronological overview of these initiatives. Most of them are focused on housing, infrastructure, public safety, and environmental management, contributing toward achieving several dimensions of the UN's SDGs 7, 10, and 11. However, it is evident that Lowell's policies and programs mostly target SDG 11, which promotes inclusive, safe, resilient, and sustainable cities and communities.

Table 1. Lowell's landmark sustainable urban transformation projects (Source: Author's compilation)

Initiative	Year / Funding	Lead Actors (Helices)	Core Objectives	Outcomes / Progress	SDG 11 Targets
Sustainable Lowell 2025 Plan	2012 – present / City funds + state grants	Gov + Community + UML‼	Integrate land use, housing, climate, public health	Multilingual participation; reduced waste (−30%); solar capacity ↑ to 30 MW	11.3, 11.6, 11.b
GoLowell Multimodal Plan	2021 / MassDOT* $165K grant	Gov + Private + Community	Redesign downtown corridors for bikes, pedestrians, transit	Quick-build pilots completed; modal-share increase	11.2, 11.7
Vision Zero & SS4A Plan	2024 / USDOT** $200K	Gov + Community + Health	Eliminate traffic fatalities; improve safety culture	Regional plan endorsed; action planning underway	11.2, 11.7
Saint Louis Sponge Park Project	2024–26 / ARPA# $682K + $929K design	Gov + UML + Community + Private	Green infrastructure retrofit; flood control in EJ area	Community engagement 2025; construction 2026	11.5, 11.7
CDBG & HOME Housing Programs	Annual (CAPER 2025)	Gov + Private + Community	Affordable housing rehab and new units	24 households assisted; 22 small businesses funded	11.1, 11.3
Community Choice Power Aggregation	2019 onward / DPU## approval	Gov + Private	Clean, affordable electricity	Citywide renewable mix adopted	11.6, 11.b
Hamilton Canal Innovation District	Ongoing / PPP! investment	Gov + Private + UML	Redevelop 15-acre brownfield downtown	Mixed-use buildout underway 2025	11.3, 11.4, 11.a

*Mass Department of Transportation; ** US Department of Transportation; # American Rescue Plan Act of 2021; ## Massachusetts Department of Public Utilities; ! Public Private Partnerships; ‼ University of Massachusetts, Lowell

The Levers of Lowell's Success – Quadruple Helix and Collaborative Governance

Apparently, Lowell's progress can be attributed to the implementation of numerous projects that strengthened infrastructure, expanded equitable economic opportunities, improved well-being, and enhanced environmental quality. However, there are several underlying drivers and mechanisms behind this success.

First, the role of shared decision-making among city government, academia, the private sector, and civil society has remained central. The Quadruple Helix innovation ecosystem and the practice of collaborative governance (Carayannis & Campbell, 2009; Ansell & Gash, 2008) enabled by this approach make civil society a co-creator of innovation. The Quadruple Helix framework extends the earlier Triple Helix model (Etzkowitz & Leydesdorff, 2000), which highlights government, industry, and academia linkages as the drivers of innovation. The four interacting subsystems i.e. government, academia, industry, and civil society in the Quadruple Helix create an open innovation environment that collectively supports technological, social, and ecological objectives (Carayannis & Campbell, 2009). In Lowell's case, the civil society helix is especially visible and deeply embedded in the city's governance and development processes. The following stakeholders were clearly identifiable in each helix.

1. **Government**: City Council, Department of Planning & Development (DPD), and sustainability offices.
2. **University**: UMass Lowell research centers and the Center for Community Research & Engagement.
3. **Private Sector**: Real-estate developers, clean-energy firms, creative-industry entrepreneurs.
4. **Civil Society**: Neighborhood groups, cultural associations, and nonprofits such as the Lowell Alliance, Greater Lowell Health Alliance, and The Lowell Plan

The fusion of these helices transformed individual projects into system innovations that deliver SDG-aligned outcomes.

Second, Lowell's stakeholders were clearly cognizant of the distinct city resources they could leverage. It is often highlighted in the traditional urban innovation research that unique local resources, such as heritage assets, institutional strength, and human capital, play a critical role in successful transformation (De Jong et al., 2015). Lowell effectively mobilized its resources as illustrated in the following (ways): historic mill complexes repurposed for high-technology startups and loft housing; a research-intensive university integrated with municipal planning; and a dense network of nonprofit and immigrant organizations that enhance community capacity. However, as sustainability imperatives intensify, cities – just like business organizations – also require adapting their competencies to learn, adapt, and coordinate across institutional boundaries (Teece et al., 1997).

Third, collaborative governance was a crucial mechanism that enabled successful implementation, monitoring, and long-term sustainability of the city's initiatives. Collaborative governance theory posits that durable public outcomes arise from collective decision-making processes that engage multiple stakeholders in consensus-oriented dialogue (Ansell & Gash, 2008, p. 544). The key drivers of such governance are trust, shared motivation, and joint capacity, which together explain how Lowell's multilingual engagement forums, neighborhood councils, and participatory budgeting initiatives maintained legitimacy and citizen trust even under fiscal constraints.

Lessons Learned and Practical Implications

Together, the Quadruple Helix and collaborative governance approaches form an integrative model long cultivated through community engagement and university partnerships - that has shortened Lowell's time to innovation, transforming policies into implementable urban experiments. The Lowell model demonstrates that when civic capacity is co-produced across these four helices, sustainability transitions can accelerate without compromising inclusivity.

The implementation of this integrated approach requires leadership's solid commitment to long-term sustainability. City leaders and managers have fostered a culture of cross-sector collaboration. Their emphasis on data transparency, participatory design, and incremental implementation confirms the collaborative capacity dimension of governance theory (Emerson et al., 2012). Similarly, the leadership of the University of Massachusetts Lowell (UML) has also positioned the university as both convener and innovator, aligning research agendas with the community's priorities in health, housing, and energy equity. This university-city partnership is a good example of the knowledge-broker function, a key feature of the Quadruple Helix dynamics (Carayannis & Campbell, 2009).

The resulting institutional learning and feedback loops have paved the way for sustained momentum while connecting the city to external ecosystems. Lowell's institutions have progressively adopted a learning-by-doing approach. For instance, the GoLowell quick-build pilots served as urban laboratories, in which temporary installations were used to test public acceptance before committing to major capital investments. The CAPER performance metrics, published annually, reinforce adaptive accountability. Lowell's Frontrunner City status has formalized these feedback loops under UN-Habitat's SDG Cities initiative, providing technical assistance, comparative benchmarking, and pathways for international collaboration. This meta-governance infrastructure further enhances Lowell's capacity to diffuse innovation regionally throughout the Merrimack Valley.

Lowell's urban transformation case study showcases the value of collaborative innovation, local capacity and inclusive governance in transforming a post-industrial city into a living lab for sustainability. Its success confirms that, while mobilization of unique local resources is important, the ability of the ecosystem to institutionalize learning, trust, and shared vision across all helices is extremely critical. As cities across the globe confront parallel challenges of equity, adaptation, and ecological transition, Lowell's model demonstrates that sustained civic partnerships and transparent, data-driven governance can significantly shorten the path from policy conception to tangible urban transformation.

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02

London, UK

How Entrepreneurial Municipal Government is curating a future-shaping Science & Technology economic ecosystem in Hammersmith & Fulham, London, UK

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Abstract This brief provides a look at how localised strategies and policies' emerged to build what is now one of Europe's most important new science & technology (S&T) innovation hubs. It considers how, in a world changing faster than ever before, municipal governments in free societies must be entrepreneurial if they hope to quickly build an S&T ecosystem that is fit to shape and face the future.

Keywords Entrepreneurial, Municipal, Innovation, Economic, S&T

Introduction

The question of what life might be like by the middle of this century inspires some fantastical answers: the end of chronic diseases, digital consciousness, the colonisation of other planets and the total automation of work, to name but a few.

Then we have to consider climate change rendering parts of our world uninhabitable or, in contrast, how the super-powers of science might revitalise parts of our damaged global environment. The breadth of life-altering possibilities is mind-blowing for both optimists and pessimists alike.

Much of what this means for societies is yet to be properly considered. The rate of change driven by the Fourth Industrial Revolution is happening thousands of times faster than any in history.

Yet the lessons from history are clear: the only societies that will enjoy strong economies and reassuring national security in this altered new world will be those that have the ongoing advancement of Science and Technology (S&T) woven into their very being.

It was this type of analysis, over 15 years ago, that led Councillor Andrew Jones (a renowned professor of economic geography) and Councillor Stephen Cowan (at that time, the elected Leader of the Opposition in Hammersmith & Fulham) to begin thinking about what they must do if the Hammersmith & Fulham (H&F) Labour political party was voted in to run their West London municipality.

Building a global economic hotspot in Hammersmith & Fulham

Hammersmith & Fulham, with a population of 185,000, is a borough with not only some of the wealthiest areas of the United Kingdom but also some of the most deprived. It is situated at the gateway to central London, just 30 minutes by Tube from Heathrow Airport, and features 15

Tube stations, established parks and open spaces, seven theatres, Europe's largest shopping mall, and three major football clubs – Chelsea FC, Fulham FC and Queens Park Rangers FC. It is the third smallest of the 32 London boroughs and has a young and diverse population, with low levels of unemployment, relatively high household income and the sixth highest mobility rate in England – indicating a significant number of residents moving in and out of the borough.

In 2014, with the election of H&F Labour to run Hammersmith & Fulham Council, Stephen Cowan became the political Leader of the borough. Councils in the UK do not typically develop economic growth strategies. England – the largest of the four nations that make up the UK – has one of the most centralised government power structures in the Western world. Jones and Cowan set a goal of convening economic growth in advanced sectors.

Jones and Cowan carefully considered the soft powers their small West London local government could deploy to deliver their objective. In doing so, they were greatly influenced by the role played by the German Länder and city-states in their economic success, and the role academia plays in Kendall Square and the San Francisco Bay Area.

While they didn't have a fully formed economic strategy, they did have a clear objective to cluster together an inclusive economic ecosystem in 'long cycle' industries. They quickly articulated their goal of being a "global economic hotspot" in science, technology, engineering, maths, medicine and media (STEM³) along with the necessary actions to achieve it.

Alfred Marshall's foundational thinking on industrial districts (Marshall, 1890) and Karl' Polani's work on the social foundations of the economy (Polanyi, 1944)) had led them to reconsider the work of Professors Henry Eskowitz and Loet Leydesdorff on the 'Triple Helix (Etzkowitz & Leydesdorff, 1995). They re-articulated it as:

1. Develop an Entrepreneurial Municipal Government
2. Attract anchor institutions
3. Grow STEM³ businesses

Putting Entrepreneurial Municipal Government into action

Jones and Cowan took the view that the council needed to be a pioneer of Entrepreneurial Municipal Government and move from being an organisation solely focused on the delivery of its statutory duties to being a force which also proactively initiates and shapes its placed-based economy.

They recognised the significance of soft powers to convene and coalesce people and organisations around their objectives. They looked to shape that vision, inspire people and organisations to be part of making it a reality and, importantly, use their resources to help make it happen.

They explain how they were fortunate to benefit from the insights and advice of one of the UK's leading entrepreneurs – and local resident – when they set out to develop their strategy. Greg Jackson CBE (Commander of the British Empire) had started a series of successful businesses. In 2015, he agreed to volunteer as Hammersmith & Fulham's Business Commissioner. At the time, he was in the process of starting Octopus Energy, which in 2025, is the UK's largest energy provider.

On Jackson's advice, Jones and Cowan changed local planning requirements so 20 per cent of all new office and laboratory space must be affordable and have flexible terms. He advised these were essential to encourage and support start-up entrepreneurs to focus on their core business offer. Hammersmith & Fulham's pro-growth planning regime has since consented 192,000 sqm of commercial space since 2017. Jackson also advised the council that it needed to establish effective business support, leading Jones and Cowan to set up Upstream Nexus – a business network which now has over 4,000 members.

Attracting anchor institutions

In 2016, Jones and Cowan led their Council to establish its key industrial strategy partnership with Imperial College London. The university's president Professor Alice Gast

was relatively new in post. An American, she had previously worked at Princeton, the University of Pennsylvania, Stanford University and the Massachusetts Institute of Technology (MIT).

Jones and Cowan's pitch to cluster an economic ecosystem around Imperial's emerging White City campus (located in the northern part of Hammersmith & Fulham) while providing their borough with high quality student accommodation, affordable-flexible office and laboratory start-up space, and attracting relevant anchor businesses was received with immediate agreement by Professor Gast. It was a serendipitous meeting of minds and added to thinking which had been going on amongst some people at Imperial since they had begun to purchase land in White City in 2009.

The municipality and the university signed a Memorandum of Understanding and their strategy was launched on 12 July 2017. Its stated aims were: the creation of 'West Tech' to establish a globally significant hub for science and technology and creative industries in White City; to encourage enterprise and innovation and drive knowledge-based growth; and to deliver inclusive "growth for all" to ensure that all residents shared the benefit from economic growth.

When Jones and Cowan started out, Imperial had a small presence in the borough. Now, Imperial is firmly established in the area and powered by their joint venture, the White City Innovation District, Hammersmith & Fulham has the fastest growing economy in London and is in the UK top ten.

The borough has benefitted hugely from the partnership with Imperial, which according to the QS World University Rankings, has risen from eighth to second best university in the world. The White City campus is cited as a key factor in that leap.

Imperial has also benefitted from being Hammersmith & Fulham's industrial strategy partner. In the simplest terms, this works because the council now points all land developers who approach it towards Imperial. As a consequence, Imperial now has several major new sites for student accommodation, laboratories and start up spaces which it would never have acquired without the council placing its partnership needs at the centre of everything it does.

Growing STEM³ businesses

There are many businesses who have experienced the benefits of Jones and Cowan's vision to make Hammersmith & Fulham a global economic powerhouse in STEM³ industries.

In 2016, when venture builder Blenheim Chalcot told Cowan that they were considering moving out of the borough, he encouraged them to meet their new partners at Imperial to discuss how they could establish specialist start-up laboratory and office space. That led to the building of Scale Space, a hugely successful community of lab-based scale-ups, thriving with a joint academic and business venture.

In 2014, Fulham FC visited Cowan to discuss their plan for a multi-storey car park under their pitch, which borders the River Thames. Instead Cowan suggested they build a new riverside stand with conference centre, hotel, gym, restaurants, cafés and bars as well as a specialist office space for a STEM³ accelerator. Fulham FC followed this advice and now hosts the FIS FinTech partnership, which includes The Markers innovation space and technology incubator.

Similarly, the developer of the famous Shepherds Bush Market quickly bought into Hammersmith & Fulham's economic plan. By 2016, the developer had brought in an operator who converted old trailers into laboratory space that can be occupied by start-ups in STEM³ industries. When new owners purchased Shepherds Bush Market, Cowan encouraged them to build student accommodation and laboratory start-up space, which they did.

The outcomes

The consequence of all this activity has been financially

significant. This small West London borough has attracted £6 billion growth investment, which to provide context, is more investment than all of the rest of West London combined. The borough is now home to leading companies such as L'Oreal and Novartis in the globally-renowned innovation district. Hammersmith & Fulham now has more spin-out start-ups than anywhere else in the UK and has curated 13,200 new STEM[3] jobs since the 2017 launch.

Breakdown of the investment:

- Life sciences - £2.5 bn
- Green and climate tech - £1.1 bn
- Cyber, AI and Fintech - £946m
- Creative, digital, film and screen - £906m

An astonishing level of economic growth – 21.3% increase to 2022 – is a consequence of all this. It's notable that Hammersmith & Fulham has attracted more green and climate tech investment than Birmingham, Manchester and Bristol combined.

Cowan is approaching other anchor institutions in Europe and North America, encouraging them to open in Hammersmith & Fulham in order to further establish the area as a place where S&T policy is redefining everything about how the people in that part of London live and work.

Upstream London and the next steps

The delivery of inclusive economic growth is at the heart of Hammersmith & Fulham's place-based strategy. The borough's most important capital was spent on the £150m EdCity project, which produced new genuinely affordable housing, a new school, and WEST, a new state-of-the art youth centre. It was built just a short distance from some of the UK's most deprived communities, yet it lies in close proximity the White City Innovation District.

Looking forward, Hammersmith & Fulham shall shortly see the world famous 19th century Olympia exhibition hall transformed in line with the borough's industrial strategy. Next year, the council will open the Civic Campus, which has start-up space for entrepreneurs, an art gallery, a concert hall, an art house cinema and lecture rooms, a public sky park, a restaurant, and study spaces for local children.

As if making a jigsaw puzzle, the investment the council is winning is being pieced together to deliver on its wider vision of an inclusive campus borough. A place where its citizens feel they can face the future with agility and where serendipitous collisions produce the innovations that drive economic growth.

In November 2024, the municipality refreshed its industrial strategy and launched the second chapter: Upstream London. It maintains its version of the triple helix to accelerate inclusive growth.

The municipality's most significant new policy is the Pathway Bond. Inspired by the African proverb, 'it takes a village to raise a child', the council has engaged businesses, institutions, and other resourceful organisations to ask them to help provide services for Hammersmith & Fulham's young people. So far, over eighty organisations have signed an agreement that sees them undertaking a series of activities: work experience, mentoring, training, use of facilities, apprenticeships, and inspiring local young people to believe in the bold new possibilities of their future.

Hammersmith & Fulham has forged co-operative growth partnerships across the globe with Barcelona (Spain), Milan (Italy), Melbourne (Australia), Buenos Aires (Argentina), Rzeszów (Poland), and Oslo and Lillestrøm (Norway). Next year, along with its international partners, the council will launch the Upstream London 2026 Expo and Economic Forum which will take place between 16 to 18 March.

Jones and Cowan set out to democratise innovation, engaging the borough's wider population and thus bringing citizens new economic opportunities. The Council's emerging Living Labs programme aims to do that and, by involving vastly more people, also helps S&T businesses quickly finesse their new products and services.

Working with property developers, the council is building housing that supports its new economic S&T ecosystem, which means building genuinely affordable housing that is open to those who are building their careers and businesses in the borough so they can live, work and socialise locally.

Out of the 9,263 homes currently approved, 4,780 will be genuinely affordable as the council scales back on London's pervading model that sees many of its new homes left empty having been sold off to overseas property speculators.

Through placemaking, the council wants to develop a beautiful public realm that works for the S&T ecosystem. As Sir Tim Berners-Lee once said, "Innovation is serendipity, so you don't know what people will make". Hammersmith & Fulham's tree-lined streets, parks and riverside pubs provide the perfect spot. But as the public realm is adapted, the importance of natural beauty and designing opportunities for free-thinking 'serendipitous collisions' are central to the economic plan.

Lessons learned: Developing and sharing the blueprint of economic success

There is much that Jones, Cowan and their team has learned since they first set out to transform Hammersmith & Fulham into a global economic centre of inclusive innovation. The biggest lesson, that there is no road map and few people who could tell them what to do, took some time to learn.

Though seminal works, such as The Rise of Innovation Districts: A New Geography of Innovation in America (Katz & Wagner, 2014) has offered inspiring insights, the blueprint of what works and what does not is currently being written by innovation districts around the world.

Sharing lessons and insights by cooperating closely with other global innovation districts is central to Hammersmith & Fulham's approach. They plan to agree what they have learnt together and set out their findings at next year's Upstream London 2026 Expo and Economic Forum which they will run together with their international partners. It is also the basis of the borough's membership of the International Association of Science Parks (IASP).

Jones and Cowan have defined and codified an operating model of Entrepreneurial Municipal Government.

Entrepreneurial Municipal Government led to the building of Scale Space, the establishment of the H&F Pathway Bond, the reshaping of Fulham FC, and Shepherds Bush Market. It is how Hammersmith & Fulham developed its close relationship with Imperial College London and how it is building new partnerships with institutions and businesses around the world. This approach has brought in thousands of jobs and billions of pounds in investment. At a time when public money is scarce, it is an essential means of getting things done.

Whether it is advanced manufacturing in Stuttgart (Germany), finance in the City of London (UK), technology and venture capital in the San Francisco Bay Area (USA), or precision chemistry and electrical machinery in Daejeon (Republic of Korea), the lesson here is very clear: it is the localised clustering of economic assets into a vibrant eco-system which produces the momentum that drives ongoing and often rapid growth.

Citizens in every country look at the quickly changing world with mixed feelings. For national and local governments everywhere, putting science & technology at the heart of their social and economic planning allows them to shape the future and to let citizens know that their government is attuned to their interests.

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03

Adelaide, Australia

Critical Assets and Processes Driving Adelaide's Innovation and Entrepreneurial Ecosystem

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Abstract

Adelaide's North Terrace stands as a prime example of how strategic precinct assets and processes can drive innovation and entrepreneurial activity. Centrally located within the city's primary business district, the precinct is underpinned by robust physical infrastructure, including extensive public transport links, high-quality public spaces, and advanced digital connectivity. These assets not only enhance accessibility and connectivity but also foster geographic colocation, facilitating collaboration among research institutions, businesses, and government. The precinct's environment promotes both tacit and explicit knowledge exchange, enabling knowledge spillover and absorptive capacity—the ability of organisations to identify, assimilate, and apply new knowledge. This, in turn, supports the creation of innovative solutions and the diffusion of ideas across sectors. By integrating high-quality facilities, smart city technologies, and accessible community spaces, North Terrace exemplifies the conditions that strengthen human capital and cultivate a vibrant innovation ecosystem. The insights from this analysis highlight the critical role of well-designed urban precincts in sustaining economic growth, enhancing competitiveness, and fostering a culture of innovation.

Keywords **Innovation precincts, Entrepreneurial ecosystems, Precinct assets and processes, Knowledge spillovers and absorptive capacity, Smart city infrastructure**

Adelaide City's innovation landscape is shaped by the interplay of its physical, institutional, and social assets, supported by processes that enable collaboration, experimentation, and knowledge exchange. The city's North Terrace precinct exemplifies how co-located institutions, social spaces, and enabling infrastructure can create a fertile environment for entrepreneurship and innovation. Understanding the assets and processes at work here provides insights not only for Adelaide's future development but also for other cities aiming to build vibrant innovation-entrepreneurial ecosystems.

Adelaide's North Terrace Precinct Assets

Stretching through the northern side of Adelaide's central business district, the North Terrace precinct acts as the city's cultural and intellectual spine, a dynamic corridor of knowledge, creativity, and enterprise. Anchored by the Adelaide Railway Station and well-served by tram and bus routes, it is highly accessible from both suburban and regional South Australia.

The precinct is home to a concentration of major institutions, including Adelaide University (South Australia's largest university following the recent merger of the University of Adelaide and the University of South Australia) Flinders University, the Adelaide Convention Centre, the State Library, the Australian Space Agency, and a range of key medical, technology, and research facilities.

At its core lies Lot Fourteen, a globally recognised 7-hectare innovation district established on the former Royal Adelaide Hospital site. Backed by AUD 790 million in government investment, Lot Fourteen has rapidly grown into a hub for high-growth industries such as space, artificial intelligence, cybersecurity, defence, and the creative industries. It is now home to more than 150 organisations and over 1,800 professionals, including more than 60 startups. The Stone & Chalk startup cluster, based within Lot Fourteen, supports much of

this entrepreneurial activity, with resident ventures having already raised over AUD 200 million in capital and reaching collective valuations of around AUD 390 million. The presence of anchor tenants such as the Australian Space Agency and the Australian Institute for Machine Learning further consolidates Lot Fourteen's reputation as a launchpad for cutting-edge innovation and deep-tech entrepreneurship.

Next in the corridor is Adelaide BioMed City (ABMC), among the largest health and life sciences innovation precincts in the Southern Hemisphere—valued at approximately AUD 3.6 billion. It supports over 2,000 researchers and employs more than 10,000 staff across its institutions. ABMC is home to anchor institutions like South Australian Health and Medical Research Institute (SAHMRI), the Royal Adelaide Hospital, the University of Adelaide's Health Sciences building, and the Australian Bragg Centre (Australia's first proton therapy facility). It also hosts a thriving entrepreneurial ecosystem of startups, accelerator programs, and industry collaborations—facilitating the translation of research into real-world healthcare solutions.

These physical assets form a strong foundation for innovation. State-of-the-art laboratories, advanced medical facilities, high-speed digital infrastructure, and well-designed public spaces create an environment primed for collaboration and discovery. Adelaide's advanced smart technology systems—such as GigCity and the Ten Gigabit Adelaide network—enable real-time collaboration with partners across Australia and the world. In the language of precinct development, these assets enhance accessibility, connectivity, and co-location—conditions that foster both formal and informal collaboration. By concentrating high-quality resources in one location, the precinct minimises barriers to accessing specialised facilities, encourages shared use, and accelerates the pace of innovation.

Institutional assets add further strength. The universities provide a constant flow of graduates and postgraduates across disciplines, while cultural institutions act as repositories of knowledge and sources of inspiration. SAHMRI and related health facilities anchor Adelaide's biomedical research, drawing both talent and funding from around the globe.

Social and cultural assets such as the Adelaide Botanic Gardens and surrounding parklands adjacent to the Torrens River also play a critical role. Recreational spaces, informal networks, public events, and engagement spaces encourage connections beyond formal structures. Cultural institutions stimulate creative thinking, while nearby cafés, coworking hubs, and public plazas serve as "collision points" where chance encounters can lead to collaboration.

Figure 1. Aerial view of Adelaide City's North Terrace
Source: architizer.com

Figure 2. SAHMRI
Source: architizer.com

Activation of Precinct Assets by Innovative Processes

Assets alone do not create innovation and entrepreneurial outcomes. They need to be activated through processes that encourage interaction and shared purpose. In the North Terrace precinct, several key processes stand out:

1. Co-location and Proximity-Driven Collaboration

The clustering of institutions within Adelaide's North Terrace precinct creates an environment where collaboration is not just encouraged, but inevitable. The close physical proximity of research organisations, teaching hospitals, government offices, and commercial enterprises removes many of the barriers—both logistical and psychological—that can slow the pace of innovation. Shared buildings, adjacent laboratories, and interconnected public spaces facilitate daily encounters that often spark new ideas and partnerships.

By bringing research, clinical care, and advanced facilities into close physical proximity, Adelaide has sharply reduced the logistical barriers that typically slow the translation of discovery into patient care. A prime example is SAHMRI. The purpose-built SAHMRI building houses approximately 700 researchers—many embedded within the same structure as the Royal Adelaide Hospital—enabling seamless transition from the lab (bench) to the clinic (bedside).

The facility itself is designed with collaboration in mind: it includes nine fully flexible wet and dry laboratory modules and is directly linked to clinical infrastructure. Its design even houses South Australia's only cyclotron on site, supplying radiopharmaceuticals for imaging and therapy daily. This spatial integration means that clinical trial sites, specialist equipment, and cross-disciplinary mentoring are available within walking distance—a configuration that dramatically reduces time and resource overhead in project coordination.

Clinical trial initiation times are shortened through SAHMRI's on-campus coordination platforms, which streamline ethics and governance processes, and through nearby facilities such as CMAX. By leveraging Australia's Clinical Trial Notification (CTN) scheme, CMAX can accelerate the progression of new products into clinical testing, offering a faster and more flexible alternative to traditional regulatory pathways.

Together, these structural and procedural advantages foster a high-throughput environment—where innovation moves rapidly from ideation to real-world application—and where patient outcomes benefit from accelerated access to the latest treatments and technologies.

Figure 3. Social spaces along North Terrace
Source: Faculty of Health and Medical Sciences – The University of Adelaide

This proximity-driven model mirrors global best practices in innovation precinct design, creating a fertile setting for both planned collaborations and serendipitous connections that might otherwise never occur.

2. Talent Circulation and Skills Exchange

A hallmark of the North Terrace precinct is the fluid movement of talent across its academic, industry, and government partners. This circulation is not merely a byproduct of career transitions—it is a deliberate and strategic feature of the ecosystem that broadens the skill base, deepens cross-sector understanding, and fosters collaborative innovation.

At the heart of this dynamic ecosystem are the newly merged University of Adelaide and University of South

Australia—Adelaide University, and Flinders University. Renowned for its research excellence and industry engagement, the universities play a pivotal role in nurturing talent and driving applied innovation. Graduate students frequently undertake industry placements with local medtech firms, gaining hands-on experience that enriches their academic work with real-world insights.

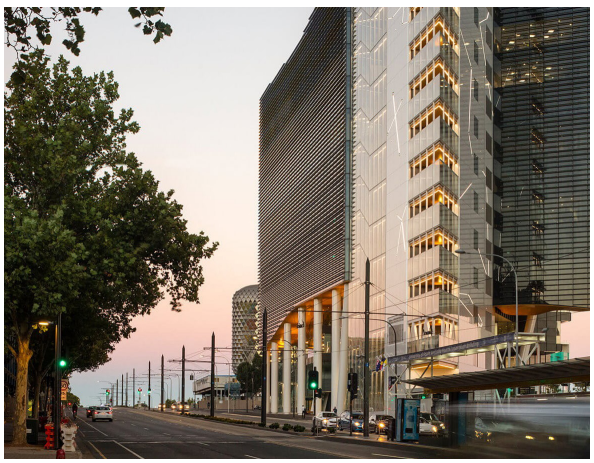

Figure 4. Adelaide University
Source: Universities Australia, Canberra.

This continual flow of people, ideas, and practices creates a vibrant skills marketplace within the precinct. The result is an agile and adaptable workforce, equipped to address emerging challenges such as scaling biomedical manufacturing or integrating artificial intelligence into diagnostic platforms. Furthermore, this exchange of personnel ensures that stakeholders across academia, industry, and government maintain a shared language and mutual trust—both of which are essential for accelerating innovation in complex, multidisciplinary fields like health sciences, where collaboration between clinicians, engineers, and data scientists is critical.

By embedding this talent mobility into its operational fabric, the North Terrace precinct enhances its resilience. When market dynamics shift or disruptive technologies emerge, the ecosystem is primed with the human capital necessary to respond swiftly, pivot effectively, and lead transformative change.

3. Facilitating Knowledge Spillovers, Absorptive Capacity, and Knowledge Creation

One of the most valuable outcomes of a well-designed precinct such as Adelaide's North Terrace corridor is the facilitation of knowledge spillovers—the unplanned and often informal transfer of ideas, techniques, and expertise between individuals, organisations, and institutions located in close proximity. This phenomenon is not merely a by-product of colocation but a strategic advantage that underpins innovation-entrepreneurial ecosystems.

ABMC has deliberately embedded mechanisms to accelerate these spillovers. Shared facilities such as the Adelaide Health Innovation Hub and university-affiliated coworking labs encourage researchers, clinicians, and entrepreneurs to collaborate informally, often leading to new project ideas or partnerships. For example, the co-location of SAHMRI's Precision Medicine group with hospital clinicians has supported data-driven oncology research that now underpins clinical trials in immunotherapy.

According to IP Australia, the state's health and medical research sector has recorded a steady increase in medical technology and biotechnology-related patent filings over the past decade, a trend linked to precinct-based collaboration. Similarly, evaluations of Lot Fourteen's entrepreneurial programs show that startups embedded within multidisciplinary hubs are more likely to secure follow-on investment compared to those outside such environments, reflecting the value of spillovers in shaping investment readiness.

By fostering an environment where researchers, industry practitioners, entrepreneurs, and policymakers interact regularly—in shared workspaces, public forums, or community spaces—the precinct catalyses the diffusion of both tacit knowledge (insights embedded in experience) and explicit knowledge (codified and shareable information). These spillovers not only enhance the rate of innovation but also strengthen Adelaide's positioning as a competitive node in the global health and biomedical innovation network.

However, for these spillovers to translate into tangible entrepreneurship, organisations and individuals must possess the absorptive capacity to recognise the value of external knowledge, assimilate it, and apply it effectively. Absorptive capacity is shaped by prior knowledge, technical skills, and the ability to integrate new insights into existing workflows. The diversity of actors on North Terrace—from academic institutions and cultural organisations to start-ups and government agencies—creates a rich tapestry of complementary expertise. When supported by collaborative platforms, shared events, and digital infrastructure such as Ten Gigabit Adelaide, the precinct maximises the conditions for actors to enhance their absorptive capacity and turn shared information into actionable innovation and enterprise creation.

Importantly, this process not only involves knowledge uptake but also drives knowledge creation. As diverse expertise converges, new ideas emerge through processes of recombination—blending concepts from different fields to create novel solutions. In precincts like North Terrace, where geographic proximity encourages sustained interaction, these moments of cross-pollination are far more frequent. A discussion over coffee between a biomedical researcher and a data scientist can lead to the conceptualisation of an AI-driven diagnostic tool; a chance meeting between an artist and an urban planner can spark innovative approaches to public space design.

These dynamics form a reinforcing cycle. The more knowledge is shared, the more opportunities there are for organisations to develop the capabilities to absorb and apply it. Consequently, the stronger these capabilities become, the greater the precinct's overall capacity for endogenous growth—innovation that arises organically from within the ecosystem itself. Over time, this not only strengthens the North Terrace precinct's position as a hub of creativity and problem-solving but also contributes to the broader economic resilience of Adelaide.

4. Entrepreneurial Support Infrastructure

Supporting this cycle of innovation is a mature entrepreneurial ecosystem embedded directly within the precinct. Incubators, accelerators, and university-led entrepreneurship programs offer far more than just desk space—they function as strategic growth engines for early-stage ventures. Startups gain access to structured mentoring, targeted capability-building, seed and pre-seed funding, and carefully curated introductions to investors and corporate partners.

In the health and biomedical domain, these programs have become increasingly specialised. They provide regulatory navigation services, guidance on clinical trial design, intellectual property strategy development, and support for manufacturing scale-up—recognising the unique challenges of bringing medical technologies to market. Flagship hubs such as the University of Adelaide's ThincLab and the University of South Australia's Enterprise Hub connect entrepreneurs with engineers, medical researchers, and data specialists, fostering multidisciplinary teams capable of delivering complex health solutions.

Cross-sector fertilisation is a defining feature of this ecosystem. Ventures focused on health innovation frequently intersect with technology accelerators and advanced manufacturing programs, producing hybrid products. One example is Fusetec, an Adelaide-founded company that produces 3D-printed human body parts—complete with realistic, anatomically accurate bone, skin, and muscle—for use as teaching aids during surgical training.

By bridging the gap between ideation and commercialisation, this entrepreneurial infrastructure ensures that promising research does not stall in the lab but reaches the patients, clinicians, and markets that need it.

5. Cross-Sector Partnerships

Many of the precinct's most successful initiatives stem from partnerships that bridge academia, industry, and government. In the health sciences cluster, these collaborations extend well beyond formal research agreements into dynamic, interconnected value chains.

Upstream, universities and research institutes work closely with medical equipment suppliers, biotechnology firms, and pharmaceutical companies to co-develop and test innovative technologies. This includes designing advanced diagnostic devices, prototyping surgical tools, and refining drug delivery systems.

Figure 5. Royal Adelaide Hospital
Source: Royal Adelaide Hospital

Downstream, the precinct's proximity to major hospitals and clinical facilities enables rapid deployment, evaluation, and feedback loops for these innovations. Companies such as CMAX, Carina Biotech, and BiomeBank conduct collaborative clinical trials involving not only medical practitioners and researchers but also patients, whose lived experiences help shape more effective treatments and products. Hospitals, in turn, provide critical real-world data that inform product refinement and regulatory approval processes.

This upstream–downstream integration ensures that innovation in the precinct is not an isolated academic exercise but part of a continuous cycle, from concept and development through testing, commercialisation, and practical application in healthcare settings. Such a system not only accelerates time-to-market for health innovations but also strengthens the region's global competitiveness in medical technology and life sciences.

Conclusion

Adelaide's North Terrace precinct vividly demonstrates how the strategic alignment of critical assets—ranging from physical infrastructure and world-class institutions to vibrant social innovation initiatives and engaged community networks—with dynamic activating processes such as collaboration, knowledge exchange, and talent circulation, can generate a powerful engine for innovation and entrepreneurship. The true value of such a precinct lies not merely in the concentration of high-quality resources but in the deliberate and effective mobilisation of these assets to create new knowledge, enhance organisational capacity, and ultimately drive sustained economic and social progress.

As Adelaide continues to deepen its commitment to fostering an innovation ecosystem, the insights gained from North Terrace offer a compelling blueprint. It becomes clear that while assembling assets is a necessary foundation, it is the interplay of processes—those intangible yet vital mechanisms of interaction, learning, and shared purpose—that transform static resources into vibrant catalysts for transformative change. Looking forward, sustaining this ecosystem will require ongoing investment not only in infrastructure but also in nurturing the social and institutional networks that enable trust, collaboration, and adaptive capacity.

By embracing this holistic approach, Adelaide is well positioned to maintain and strengthen North Terrace as a globally competitive innovation precinct—one that not only generates cutting-edge research and entrepreneurial ventures but also contributes meaningfully to community wellbeing and resilience in an increasingly complex and interconnected world.

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04

Lima, Peru

From Congestion to Connection: How Lima is Advancing Sustainable Mobility and Digital Cities

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Abstract

This article analyzes Lima's strategic efforts to transform its critical urban transport system and address the digital divide inherent in a megacity characterized by high informality. The transformation is articulated through science- and technology-based innovation, highlighting two core pillars: electromobility and digital governance.

On the sustainability front, the paper examines public-private sector collaboration to introduce clean fleets. In the digital sphere, the key measure of success lies in the centralization of the Urban Transport Authority for Lima and Callao (ATU), a crucial regulatory step designed to unlock interoperability and the use of modern payment systems.

Advances in institutional integration and private investment serve as indicators of progress. However, the Lima case reveals that technological innovation must be designed for inclusion, as digital fragmentation and the low coverage of formal systems risk exacerbating inequality. The case offers transferable lessons on how the prioritization of digital governance must precede technology to achieve sustainable and inclusive mobility in complex metropolitan contexts.

Keywords **Digital Governance, Urban Mobility, Electromobility, Unified Collection System, Urban Inequality**

1. Context and Challenges

Lima, the capital of Peru, stands as one of the largest megacities in Latin America. With a population exceeding 10 million inhabitants in its metropolitan area, the city is the main economic and political hub of Peru (INEI, 2024). Rapid demographic growth and the concentration of economic activities have generated a complex urban structure characterized by pronounced spatial inequality (Wiese et al., 2017). This is evidenced by the fact that the Gini coefficient is approximately 0.46, which indicates the level of inequality in the distribution of income within a population, and the per capita income in central districts such as San Isidro is more than eight times higher than in peripheral districts like San Juan de Lurigancho (INEI, 2024).

The urban transport system in Lima faces a critical situation marked by structural challenges with deep social and economic impacts. Every day, around 24.5 million trips are made in the city (PUCP, 2021), yet the insufficient road infrastructure, the high dependence on informal or semi-formal public transport, and the constant increase in the vehicle fleet produce severe congestion. As a result, about 10% of Lima's residents spend between one and a half to three hours on a single trip (CIES, 2016), significantly reducing both quality of life and productivity (MEF, 2018).

Furthermore, urban informality—a persistent characteristic of Lima's spatial growth—intensifies inequities in mobility conditions, especially in peripheral low-income areas where residents face longer trips, more transfers, and higher relative costs (Robert et al., 2022). These conditions restrict access to essential services, employment, and goods, thereby reinforcing socio-spatial inequalities and limiting inclusive urban development (Rodriguez et al., 2023).

These mobility challenges in Lima also reflect broader global urban issues that demand innovative and technological responses. The city's high congestion levels and car-centered planning, combined with the use of older vehicles, contribute significantly to air pollution and carbon emissions, mirroring worldwide concerns that

Figure 1. Traffic in Lima exceeds that of cities like Bogotá, Santiago de Chile, and Mexico City (GEC, 2024)

cities are tackling through the promotion of sustainable and healthy mobility (Poma Salazar, 2021). Additionally, Lima faces a pronounced digital divide in transport management, marked by the absence of integrated information systems, limited adoption of intelligent transport technologies, and barriers to digital access that prevent full citizen participation in mobility solutions (Vela Vargas et al., 2023).

Consequently, this article focuses on the city of Lima's efforts to address two critical urban challenges: mobility and digital transition. It highlights initiatives such as the introduction of sustainable transport measures, including electric buses, as well as the ongoing digital transformation of urban public services. Emphasis is placed on collaborative efforts between government entities, municipalities, international partners, and the private sector, along with lessons that may be drawn for other metropolitan contexts.

2. Strategy

In this context, urban innovation and strategic planning emerge as an indispensable pathway toward a more sustainable, inclusive, and safe transport system. This vision aligns with the national public policy framework, specifically the National Strategic Development Plan (PEDN) 2050 of the National Center for Strategic Planning (CEPLAN).

National Objective 2 of the PEDN 2050 focuses on the management of a "Sustainable Territory," which aims to create safe environments with the intensive use of knowledge and communication technologies. More importantly, National Objective 3 focuses on the need to "Increase competitiveness and productivity" through the intensive use of science and technology and the country's digital transformation. These guidelines promote coordinated governance for territorial and urban management, where accessible, sustainable, and safe mobility constitutes a fundamental pillar to guarantee the right to the city and the full development of human capacities (PUCP, 2021; CEPLAN, 2022).

Lima's response to its structural challenges of mobility, congestion, and inequality is articulated through an innovation strategy that seeks to leverage science and technology as key tools for urban transformation, thus aligning with National Objective 3 of the National Strategic Development Plan 2050 (CEPLAN, 2022).

In addition, its urban policy has progressively moved toward the adoption of Science- and Technology-Based Solutions (STBS) and the promotion of Intelligent Transport Systems (ITS), although implementation still faces challenges (MTC, 2021). The main technological solutions in progress focus on two critical areas: electromobility to combat pollution and digitalization of management to improve efficiency.

3. Implementation

The transition toward sustainable mobility and electromobility in Lima represents a significant STBS aimed at reducing air and noise pollution generated by the city's aging transport fleet (Poma Salazar, 2021). The ATU has initiated the integration of 100% electric buses into the city's ITS, a step that not only lowers the carbon footprint but also functions as a pilot project for clean technologies and energy efficiency (ATU, 2023). These

vehicles reflect incremental innovation within existing infrastructure, enhancing the service quality for formal transport users.

Moreover, associated technologies such as real-time GPS tracking and fleet management systems enable better monitoring and operational efficiency. However, their overall impact remains constrained by the limited coverage of formal transport, which accounted for only 14.3% of trips in 2022, and by the absence of a fully consolidated ITS (REDES, 2023).

MODASA – Peruvian Innovation Driving Urban Electromobility

A National Milestone: The "Made in Peru" Electric Bus

The Peruvian company Motores Diesel Andinos S.A. (MODASA) has established itself as a key player in the country's energy transition. The centerpiece of its innovation strategy is the development and launch of its line of 100% electric buses, such as the ETitán model. This achievement results from significant investment in research and development, supported by tax incentives under Law No. 30309, demonstrating the capability of Peruvian engineering to compete globally.

- **Sustainability and Efficiency Results:** MODASA's electric buses (ETitán and other models) produce zero greenhouse gas emissions during operation, providing a vital solution to Lima's critical air quality issues. In addition, they achieve operating cost reductions of up to 60% compared to equivalent diesel buses.
- **Strategic Scope**: The company targets not only urban transport in Lima and Callao, where units have been piloted on major corridors, but has also achieved a major innovation milestone by introducing the first electric buses for personnel transport in the mining sector, illustrating the adaptability of its technology to Peru's challenging geographical conditions.

The MODASA case highlights the potential of collaboration between the private sector and public institutions, such as the ATU, in driving urban electromobility and sustainable transport solutions.

Figure2. ATU presents the first electric bus manufactured in Peru as a step toward sustainable mobility (El Peruano, 2023)

To overcome the fragmentation and inefficiency that characterize Lima's urban transport system, the city's innovation strategy emphasizes the digital transformation of mobility and public management services (ATU, 2023). One of the main initiatives involves the implementation of a unified electronic fare collection system, designed to integrate various modes of transport—including the Lima Metro, Metropolitano, and Complementary Corridors—through interoperable smart cards. This measure not only simplifies access for users but also generates valuable mobility big data, which supports urban planning, policy evaluation, and route optimization (IDB, 2022).

In parallel, there are ongoing efforts to strengthen data integration, with the development of a regulatory framework and technological infrastructure—such as

fiber-optic networks—to enable intelligent traffic lights and real-time information systems, crucial tools for reducing congestion and improving travel efficiency (MTC, 2021).

The ATU and the Digital Unlocking of Transportation in Lima

The ATU has achieved a crucial milestone by overcoming the historical fragmentation of fare payment systems in Lima. The main accomplishment was the establishment of a legal framework mandating integration by private operators. This progress was formalized with the approval of the Regulations for the Unified Fare Collection System (SRU) (ATU, Res. No. 130-2024-ATU/PE).

The digital governance strategy of the ATU aims to improve user experience and operational efficiency through the integration of payments, promotion of digital financial inclusion, and reduction of road safety risks.

Figure 3. ATU unified card (ATU, 2025)

The implementation of Lima's innovation strategy has relied on collaboration among diverse actors while confronting institutional resistance and the persistence of informality in the transport system. A major step was the creation of the ATU to centralize mobility management. The process has been supported through public-private partnerships (PPP)—responsible for the introduction of electric buses and digital fare systems—and through international cooperation with institutions such as the Inter-American Development Bank (IDB) and the Andean Development Corporation (CAF), which have provided both technical and financial support. At the local level, several municipalities have promoted micromobility initiatives and pedestrian infrastructure, strengthening decentralized innovation (PUCP, 2021).

In terms of results, the ITS shows an advanced stage of operational integration, though full interoperability remains a medium-term objective. The renewable fleet efficiency indicator highlights progress in compressed natural gas adoption and the gradual incorporation of electric buses, achieving full fleet renewal in certain consortia.

The ATU has also leveraged USD 433 million in private investment for three cable car projects in Lima and Callao under PPP schemes. Meanwhile, micromobility coverage expanded by +123 km between 2020 and 2024, reflecting municipal leadership and external financing. However, the User Satisfaction Index reveals that despite improvements in formal systems, overall satisfaction remains limited due to low service coverage.

4. Lessons

The case of Lima provides valuable insights for other developing megacities seeking to modernize their transport systems, offering lessons on how to build sustainable mobility systems while closing the digital and institutional divides that constrain urban development.

The main lesson is that technology alone cannot close the mobility gap without a strong, unified transport authority capable of formalizing routes and ensuring interoperability (REDES, 2023). The ATU serves as the institutional response, but its effectiveness depends on its ability to coordinate multiple stakeholders.

Moreover, digital solutions must be designed for inclusion. The success of digital systems (e.g., real-time information

apps) relies on narrowing connectivity gaps in peripheral areas and improving digital literacy among low-income users (CAF, 2021). Otherwise, technological innovation could paradoxically deepen existing inequalities.

In addition, the relatively high cost of electromobility requires a regulatory framework of incentives (subsidies and exemptions) and a clear energy policy to be sustainable and scalable in the long term, transforming an environmental challenge into an opportunity for technological development.

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05

Montréal, Canada

Living with Water: Montréal's Nature-Based Approach to Strengthening Urban Resilience

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Abstract

Montreal faces a new hydrological reality shaped by two converging pressures: the large-scale mineralization of its territory and increasingly intense rainfall driven by climate change. Built over nearly two centuries, the city's sewer network–now aging and often undersized for extreme events- can no longer absorb peak flows generated by urban runoff. In response, Montreal is shifting from an underground, conveyance-based model to a surface-level strategy rooted in retention, infiltration, and nature-based solutions.

Central to this transition is the development of "sponge parks," multifunctional public spaces designed to temporarily store, infiltrate, and filter stormwater while improving urban livability. The Pierre-Bédard resilient park serves as a flagship pilot, demonstrating how hydraulic performance, environmental benefits, and social co-benefits can be combined within a northern-climate context.

Montreal's experience also shows that adaptation accelerates through standardized design practices, such as draining curb extensions, supported by interdepartmental collaboration and a cultural shift toward embracing water as part of the urban landscape.

Keywords Urban resilience, Nature-based solutions, Stormwater management, Sponge parks, Climate adaptation

1. A Historic City Facing New Hydrological Challenges

Beneath Montréal's streets, 4,600 km of pipes form the sewer network of a city built on an island since the 17th century. This underground system, one of the largest in Canada, was developed gradually over nearly two centuries. Some of these infrastructures - sometimes over a hundred years old - are still in use, but they now face a challenge their designers never anticipated: 21st-century rainfall.

For a long time, the network was sufficient.

Montréal, founded in 1642, developed around the Saint Lawrence River with a relationship to water that is both intimate and constrained. The first sewer pipes were built in the 1830s, when the city had barely 30,000 inhabitants. Even today, many main pipes date from before 1960- an impressive technical legacy, but one that is aging in a profoundly transformed territory.

Urbanization: a transformed landscape

Since the 1950s, Montreal has expanded far beyond its historical core, following a horizontal, North American pattern of urbanization.

Agricultural and natural soils were progressively replaced by impermeable surfaces—roads, parking lots, rooftops—while the city lost more than 75% of its wetlands, once natural sponges for stormwater.

By now, only a quarter of these ecosystems remains, mainly in the eastern part of the island.

This large-scale mineralization has reduced the soil's natural infiltration capacity by more than 50% since the 1970s, mechanically increasing the volumes of rainwater flowing toward the network.

Climate change: rain that falls faster and harder

A second transformation is climatic.

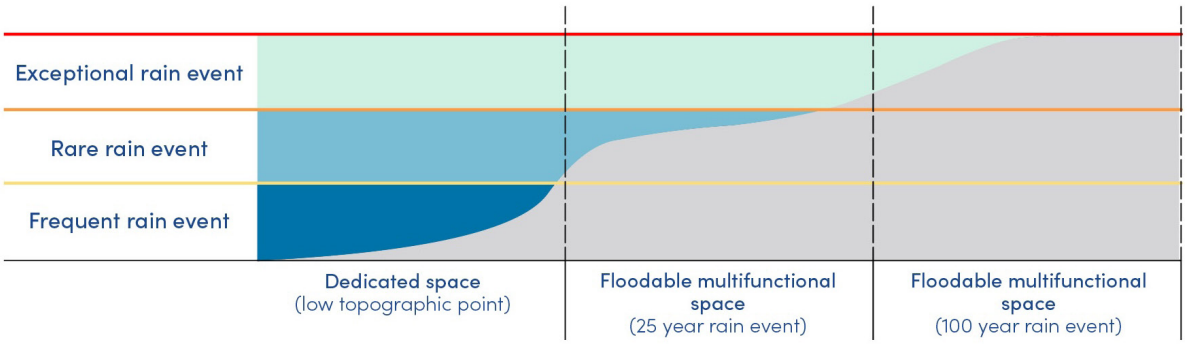

Figure 1. Reduced soil infiltration capacity as impermeable surfaces expand (City of Montréal)

Extreme weather events have grown in both frequency and intensity.
Rainfall totals that once accumulated over a full month can now occur within a few hours. In 2023, some Montreal stations recorded **over 90 mm in two hours**—levels incompatible with a network designed for a far more stable climate.

This trend is global. According to the World Meteorological Organization, intense rainfall events are now **30 to 40% more frequent**, and economic losses resulting from water-related damage have increased eightfold since 1970.

Hydraulic bottlenecks in dense urban basins

In many neighborhoods, water flowing from streets, roofs, and parking lots naturally converges into low-lying areas.
Even with conduits up to four meters in diameter, peak flows caused by today's extreme rainfall exceed the capacity of the system — a challenge also highlighted by **Hervé Logé**, *Director, Asset Management – Water Department, City of Montréal.*
Hydraulic bottlenecks form, leading to sewer backups, overflowed street drains, and localized flooding.

A new equation

Montreal now faces a combination of pressures:

- an increasingly impermeable territory
- increasingly intense rainfall
- an aging network designed for another era

It is this combination—more than any single factor—that now forces the city to rethink how it manages water.

2. A New Generation of Green Infrastructure: The "Sponge Parks"

Rather than trying to fight water, Montreal has chosen to learn to live with it.

This shift in perspective marks a major break from the traditional logic of urban engineering: the goal is no longer to expel water as quickly as possible, but to integrate it into the urban system.

Global inspiration: the "sponge city" movement

This approach is part of a global wave of innovation, inspired in part by international initiatives such as China's "sponge city" strategy and similar nature-based approaches adopted elsewhere, launched in the 2010s.
In cities like Wuhan and Shenzhen, authorities adopted a simple but radical principle: **allow water to infiltrate, evaporate, or be reused**, rather than resisting it.

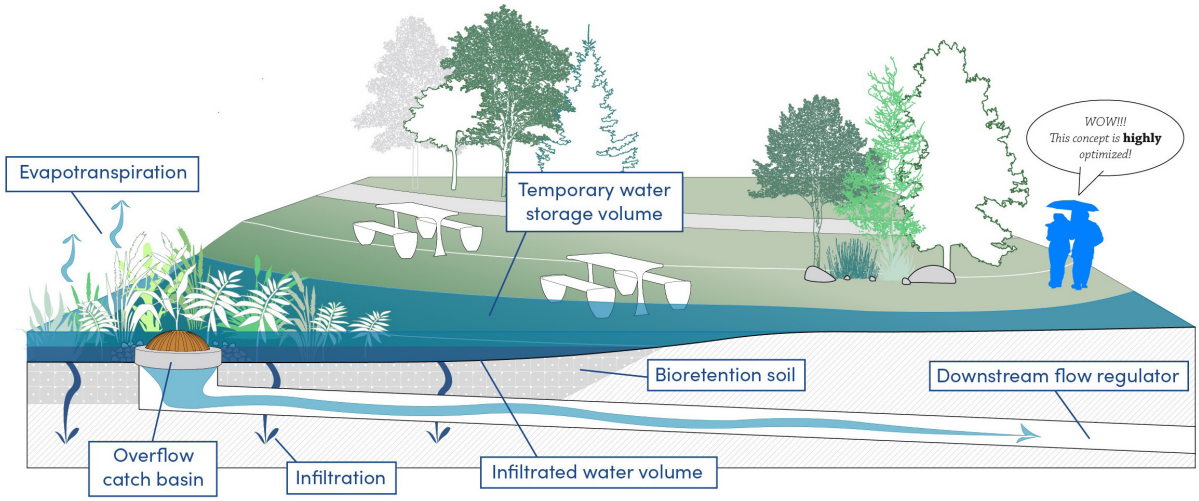

Figure 2. Schematic of temporary water retention, infiltration, and the bioretention processes in a sponge-park system

A made-in-Montreal adaptation

In Montreal, this philosophy was adapted to the realities of a **northern climate.**

The local strategy combines:

- **retention**
- **infiltration**
- **surface-level management** of rainwater where it falls

As Professor Sophie Duchesne at INRS summarises:

"We need to reshape our streets and redesign our neighbourhoods so that excess water can be directed to places where it does not disrupt daily life."

Hybrid infrastructures: green and grey

Sponge parks are part of a broader family of surface-based infrastructures that now includes:

- permeable or draining streets
- green alleys
- vegetated swales
- certain **grey infrastructures**, such as skateparks whose geometry can temporarily retain stormwater

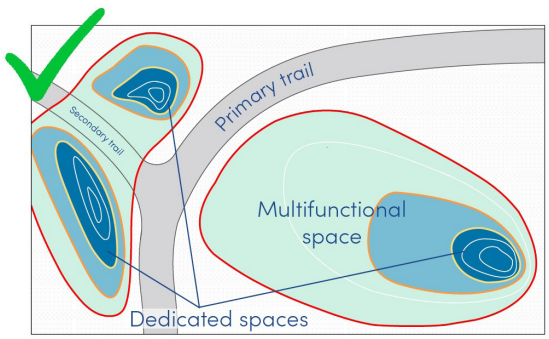

Figure 3. Surface-based stormwater management: dedicated vs. multifunctional retention areas (City of Montréal)

Together, they form a **hybrid system** designed to manage water **on the surface**, not exclusively underground.

Benefits of these multifunctional infrastructures:

- temporarily absorb rainwater
- naturally filter pollutants
- reduce stormwater runoff
- create accessible green spaces

Integrated into the urban fabric, they function as **open-air retention basins**, slowing and filtering water before it reaches the sewer network.

This marks a shift **from underground engineering to surface-level resilience,** treating nature as an active partner in city planning.

3. Pierre-Bédard Park: A Montréal Laboratory for the Sponge City

This philosophy takes concrete shape in Montreal through several pilot projects led by the Water Department and the Large Parks Directorate.

The most emblematic is the **Pierre-Bédard resilient park**, located in Mercier–Hochelaga-Maisonneuve.

Figure 4. Overview of the Pierre-Bédard resilient park, designed to absorb and temporarily retain stormwater

Here, a public space has been redesigned as a multifunctional green infrastructure capable of **absorbing, filtering, and temporarily storing** stormwater from the surrounding neighborhood.
Rather than directing water to the sewer network, the site captures and treats it naturally while offering recreational space, biodiversity, and public education.

This project—carried out with MAMH and MELCCFP—represents an investment of approximately **$15 million.**

The park includes:

- temporary storage basins
- vegetated infiltration areas
- draining swales
- monitoring system to evaluate performance by 2027

Figure 5. Vegetated infiltration area within Pierre-Bédard Park (City of Montréal)

A northern-climate adaptation

Montreal also adapts this model to seasonal realities specific to northern cities, including intense spring and autumn rainfall and rapid spring snowmelt.

Sponge parks act as seasonal buffers, reducing runoff and limiting sewer overload caused by meltwater.

A triple objective

The sponge-park model supports a triple ambition:

Environmental:

- fewer overflows into the St. Lawrence River
- improved water quality and biodiversity
- reduced heat islands

Economic:

- lower cost than a full separate-sewer system
- prevention of damage-related expenses
- development of municipal expertise in nature-based solutions

Social:

- greener neighborhoods
- enhanced public spaces
- community participation in design processes

Montreal plans to develop **around 30 sponge parks,** in addition to the eight already built or underway.

Beyond hydraulic performance, these initiatives represent

a cultural shift: a city learning to *live with water* rather than fight it.

4. From Infrastructure to a Water Culture: Lessons and Operational Implications

Montreal's experience highlights a key lesson—one fully aligned with DISTEP's recommendations: **standardization is the most powerful lever for accelerating urban adaptation.**

As noted by Water Department experts, Montreal moved from isolated pilot projects to widespread implementation through the **standardization of design practices.**
A defining example is the citywide adoption of standardized draining curb extensions, whose dimensions, materials, and integration guidelines are now systematically applied in every street or park redevelopment.

Figure 6. Standardized draining curb extension designed to retain and filter stormwater at street level

This shift enables:

- faster deployment
- lower design costs
- consistent performance
- easier adoption by municipal teams
- integration of resilience into everyday planning

As Marie Dugué, Head of Section — Planning and Major Projects, City of Montréal explains:

"Every drop counts, and by multiplying interventions in our street and park projects, we strengthen the city's resilience."

A cumulative and replicable strategy

This cumulative logic is essential: each redesigned street or park becomes part of a distributed network of micro-interventions that, together, significantly increase the territory's capacity to manage water.

Montreal's experience also underscores several operational principles:

- strong collaboration between planning, engineering, public works, and green-space teams
- organizational change through training and internal communication
- clear documentation and dissemination of standards

More broadly, Montreal demonstrates that climate adaptation is not only technical—it is cultural.
It requires a new relationship with water: making it visible, accepting its presence, and integrating it as a structuring element of public space.

Sponge parks and draining curb extensions are not just engineering solutions;
they embody a new urban philosophy rooted in **resilience, nature, and repeatable interventions.**

We cannot stop the rain from falling, but we can learn to welcome it better.

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06

Grenoble, France

Grenoble: An Innovation Hub Where Technology and Talent Converge

Building Future-Oriented Innovation Platforms through Large-Scale Research Infrastructures

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Abstract

This brief examines how Grenoble, France, has evolved into a leading innovation hub, strategically leveraging large-scale scientific infrastructure as a catalyst for profound urban transformation. Unlike a traditional policy paper, this analysis delves into the intricate processes, collaborative ecosystems, and interconnected structures that enabled the European Synchrotron Radiation Facility (ESRF) and the Grenoble Innovation for Advanced New Technologies (GIANT) campus to not only thrive as world-class research centers but also to fundamentally reshape the city's economic, social, and cultural landscape. By exploring the unique governance models and strategic investments that fueled Grenoble's success from its industrial past to its current status as a global science and technology leader, this brief offers actionable insights and universal lessons for other cities aspiring to foster innovation-driven growth, moving beyond mere infrastructure development to achieve holistic, sustainable urban evolution.

Keywords Grenoble, urban innovation, science and technology, ESRF, GIANT Campus

The Unfolding Story of Grenoble's Transformation

Grenoble, a mid-sized city nestled in the French Alps, exemplifies how strategic vision and collaboration can drive urban transformation. Facing industrial decline, global competition, and concerns like talent drain in the late 20th century, the city made a pivotal shift. It transitioned from an industrial past to a science and technology-based innovation hub. This evolution was no accident; it stemmed from pioneering research infrastructure, strong international cooperation, and meticulous urban planning. At the core of this shift is an interconnected network of world-renowned institutions like the European Synchrotron Radiation Facility (ESRF), the GIANT (Grenoble Innovation for Advanced New Technologies) Campus, the Centre national de la recherche scientifique (CNRS), the French Alternative Energies and Atomic Energy Commission (CEA), and the Micro and Nanotechnology Innovation Campus (MINATEC). This brief explores Grenoble's success, showing how a city can be transformed by strategically integrating large-scale research facilities like the ESRF into its development.

Figure 1. Grenoble Cityscape and Innovation Ecosystem Map

From Industrial Past to a Hub of Science and Technology Innovation: A Deliberate Evolution

Grenoble's urban innovation is firmly anchored in its robust science and technology infrastructure, a legacy meticulously built over decades. The concentration of S&T industries began in 1956 with the establishment of a key research institute by the CEA. Major research institutions like the CNRS and the INPG (now Grenoble Institute of Technology) followed, fostering an academic and research ecosystem, further solidified by companies like Schneider Electric and STMicroelectronics. A defining moment in Grenoble's trajectory was the establishment of the ESRF in 1988. This monumental project was a testament to international collaboration, realized through joint investment from multiple European Union member states and substantial support from the French government. The success of the ESRF attracted further large-scale research facilities, including the MINATEC, the ILL, and the EMBL, which were intensively located in Grenoble after 2001. By the mid-2010s, these concentrated efforts positioned Grenoble as a leading model for "knowledge-based urban innovation" in Europe (ESFRI, 2018), showcasing how strategic foresight and sustained investment can transform a city's fundamental identity.

ESRF and GIANT: Catalysts for Breakthroughs and Collaboration

At the very heart of Grenoble's innovation ecosystem lies the ESRF, a world-class synchrotron accelerator jointly funded by 22 European countries. It stands as one of the most powerful 4th-generation synchrotron light sources globally, providing unparalleled, cutting-edge infrastructure for fundamental and applied science. The ESRF's strength lies in its unique structure, designed to directly link fundamental research with practical industrial innovation. Complementing the ESRF, leading French research institutions and technical universities (the CEA, the CNRS, and the MINATEC) collaboratively built the GIANT integrated campus. GIANT is far more than a collection of buildings; it is a comprehensive platform meticulously designed to integrate strategic collaboration, facilitate joint projects, enable sophisticated spatial planning, and promote seamless talent exchange among its constituent institutions (GIANT, 2024). This campus epitomizes the intentional creation of an environment where interdisciplinary synergy thrives.

Beyond its infrastructural benefits, the ESRF's new "Extremely Brilliant Source" (EBS) introduced in 2020 offers a unique research environment for solving complex global problems in health, new materials, clean energy, and climate change[1]. Global corporations and innovative European SMEs collaborate with the ESRF, achieving breakthroughs in new material development, product improvement, and manufacturing process innovation. The ESRF also operates dedicated Industrial Beamlines[2] for private companies, making practical contributions to innovation and corporate competitiveness. For example, leading European corporations such as Airbus, Michelin, L'Oréal, Siemens, and Bosch actively utilize the ESRF's advanced structural analysis technology. Their applications range from high-performance component development and new material verification to intricate cosmetic molecular structure analysis, leading to numerous successful technology transfers and joint patent applications (ESRF, 2024).

1. Through the new 'Extremely Brilliant Source' (EBS) introduced in 2020, ESRF provides a unique research environment that can contribute to solving complex global problems faced by humanity, such as health, new material development, clean energy, and climate change.
2. Industrial Beamlines are specialized experimental facilities within large research infrastructures like ESRF, meticulously designed and optimized to address the specific research and development needs of industrial clients. These beamlines accelerate corporate innovation in areas such as new material development, product improvement, and manufacturing process innovation, effectively bridging the gap between fundamental research and industrial application.

This integrated strategy organically connects the scientific and technological ecosystem with the broader urban environment, encompassing residential areas, robust startup support mechanisms, and efficient transportation networks. The ESRF, in particular, actively generates industrial collaboration outcomes through targeted joint research programs and customized services tailored for diverse industrial demands. The tangible results are clear: over the last two decades, Grenoble's R&D personnel have more than doubled, and its high-tech startup rate consistently surpasses the French average. Furthermore, increased international collaborative research and publications emphatically highlight Grenoble's role as a vibrant and globally recognized innovation hub, extending its influence far beyond its physical infrastructure.

Analysis and Key Lessons from the Grenoble Model

Grenoble's transformation is a testament to multi-decade strategic planning. The ESRF's establishment in the 1980s attracted global researchers, and GIANT's development from the 2000s actualized the S&T innovation cluster. Consequently, Grenoble became France's top city for R&D investment and one of the highest in patent applications per capita in the country as of the 2020s.

The ESRF annually hosts around 10,000 scientists, and global firms like Airbus, AstraZeneca, and Siemens are major industrial users, demonstrating how ESRF's collaborative model bridges fundamental research and industrial technology application. Meanwhile, GIANT facilitates multi-layered collaboration among universities, research institutes, and companies, encompassing joint R&D, co-supervised doctoral programs, and research commercialization. This comprehensive approach is a model for industry-academia-research cooperation, cited in EU Horizon programs and OECD R&D policy reports. As noted, ESRF's dedicated industrial beamlines provide optimized measurement techniques and support for sectors like aerospace, healthcare, food, and chemicals, involving joint research, validation, and quality assurance.

Table 1. Examples of ESRF Industrial Collaboration and Key Industrialization Achievements

Industrial Sector	Company Name	Content and Achievement Summary
Aero-space	Rolls-Royce (UK)	Utilized for fatigue crack structural analysis of aircraft engine components, contributing to improved durability and design optimization.
Construc-tion/Ma-terials	Saint-Gobain (FR)	Visualization of microstructure in architectural glass, development of high-strength/lightweight composite materials, and process improvement.
Health-care/ Medical Devices	Siemens Health-ineers (DE)	Analysis of radiation response structure in CT/MRI core components, leading to improved image resolution and reduced radiation exposure design.
Food	Nestlé (CH)	Analysis of moisture distribution and crystallization patterns in powdered products, enhancing storage stability and optimizing production lines.
Energy/ Chemical	Total Ener-gies (FR)	Microstructure analysis of catalyst materials, improving reaction efficiency and developing sustainable technologies.
Health-care	Philips Healthcare (NL)	Structural analysis of biomaterials and verification of new material application in MRI devices, enhancing medical equipment accuracy.

GIANT serves as the core operating platform, supporting over 200 startups and spin-off companies annually. Collaboration via shared facilities like 'Open Lab' is increasing. GIANT functions as a governance entity and strategic coordination body, involving nine institutions, including the CEA, the CNRS, the ESRF, the ILL, the EMFL, Grenoble INP, Université Grenoble Alpes, to ensure policy

consistency. Its governance system aligns urban planning, spatial development, and human resources through regular consultations with city and regional governments.

This model redesigns the urban structure based on S&T, forming an innovation-living hybrid zone where people live, work, and research. This integrated approach attracts skilled talent and businesses while promoting physical and social integration with residents. The GIANT secretariat acts as a communication channel for external stakeholders, playing a decisive role in attracting projects and funding.

Characteristics and Strengths of the Grenoble Case

Grenoble's characteristics lie not just in attracting scientific infrastructure but in using it for city-wide structural transformation. Connecting global S&T hubs like the ESRF, the MINATEC, and the CEA into a single cluster and establishing a supra-regional GIANT governance system are the key differentiators of the Grenoble model. Large research infrastructures, like the ESRF, can be innovation catalysts transforming urban structures beyond scientific achievements, contributing to job creation, industrial base strengthening, and urban brand value.

Lessons on Structural Conditions for Urban Innovation

Grenoble illustrates that urban innovation succeeds when elements like governance, human resource circulation, technology transfer, and industrial connectivity operate simultaneously. GIANT's structure fosters continuous identification of common agendas, long-term planning, and resource allocation by government, academia, and industry. This structural stability ensures innovation continuity. Local talent cultivation and improved living conditions are also crucial. Urban innovation requires essential educational, cultural, and residential infrastructure for continuous highly-skilled personnel inflow– key aspects of soft infrastructure in which Korea has lagged.

Institutional Implications for Global Cities

The division of roles between national strategy and regional governments in France is noteworthy. The ESRF was EU/central government-funded, but regional linkages (city-university-industry) generated jobs and branding. This highlights the importance of combining top-down resource investment with bottom-up innovation demand. The framework established in Grenoble offers a valuable model for global cities designing their own innovation cluster policies. Sustainable urban innovation, like the ESRF-GIANT model, requires guaranteed legal status and continuous funding for public-private-academic partnerships.

Universal Applicability: The Grenoble Model as a Blueprint

The Grenoble model's success provides a blueprint highly applicable to various cities with similar conditions. For instance, cities with a high concentration of R&D infrastructure, such as Daejeon and Ochang in South Korea, are well-positioned for an advanced experimental facility-based industrialization strategy. However, any city aiming to emulate this model requires stronger public-private collaborative governance and earlier industrial sector participation. This serves as an important comparative model given that accelerator clusters often suffer from loose and one-directional industry-academia-research linkages. Multi-institutional strategic alliances like GIANT offer significant implications for overcoming research institution-centric operations and integrating education, industry, and policy. Specific implementation measures like joint KPI(Key Performance Indicator) setting, integrated secretariat operation, and Open-Lab-based demonstration support are worth considering for cluster governance in any city.

In summary, the GIANT campus, built around large-scale research facilities like the ESRF, is a world-class model in institutionalized collaboration, flexible innovation based on shared resources, and stakeholder-centric integrated

governance. These are strategic components for S&T-centric urban policy. This report analyzed Grenoble's urban innovation drivers (the ESRF, GIANT, and the role of governance) to propose policy recommendations for a global urban innovation strategy. It emphasizes that for any emerging innovation hub, a comprehensive consideration of strategic linkage, spatial integration, industrial collaboration, and internationalization is crucial, beyond mere technology adoption or infrastructure. For cities to achieve a science-based urban innovation model like Grenoble, strong governmental political will, enhanced regional capabilities, and institutionalized industry-academia-research cooperation are essential.

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07

Ulaanbaatar, Mongolia

Ulaanbaatar's Digital Leap: Urban Innovation and Fintech Growth

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Abstract

This article explores Ulaanbaatar's central role in advancing Mongolia's digital transformation, highlighting the capital's leadership in building smart government infrastructure, expanding digital financial inclusion, and fostering innovation ecosystems. Confronted with bureaucratic inefficiency and regional disparity, Mongolia has prioritized the modernization of public services and the integration of digital technologies into governance and economic development. Guided by national frameworks such as Vision 2050 and the Digital Nation Roadmap, Ulaanbaatar has implemented flagship initiatives including the Smart Government Project, E-Mongolia, and the expansion of Science, Technology and Innovation (STI) parks, supported by interoperable data systems and regulatory reforms. These developments have strengthened transparency, efficiency, and citizen engagement, positioning the capital as the driving force of Mongolia's digital future. At the same time, the city's growing fintech and innovation sectors, anchored by institutions such as the Socratus Startup Studio and the National IT Park, have expanded access to financial services, empowered entrepreneurs, and enhanced Mongolia's digital competitiveness. Together, these efforts illustrate how Ulaanbaatar is shaping a model of digitally enabled governance and innovation-driven urban growth for emerging economies.

Keywords Digital Transformation, Fintech, Urban Innovation, Smart City, Regulatory Reforms

Introduction

Mongolia has long faced structural barriers to achieving balanced national development. With a population just over 3.5 million, nearly half residing in Ulaanbaatar, it is one of the most sparsely populated countries in the world (World Population Review, 2025). This demographic imbalance, combined with a legacy of bureaucratic inefficiency and a natural resource-dependent economy, has impaired service delivery and widened regional gaps. Yet these same challenges have made Ulaanbaatar an experimental ground for modernization, where digital transformation has become both a necessity and an opportunity.

Over the past decade, the capital has undergone a remarkable digital shift reshaping its governance and economy. The fintech sector, in particular, stands out for driving innovation and expanding financial inclusion. This transformation is guided by Mongolia's long-term Vision 2050 (Figures 1 and 2), a national development strategy aimed at achieving sustainable and inclusive growth, and the 'Digital Nation' concept, a five-year roadmap (2022–2027) designed to integrate advanced technologies across public and private spheres. Together, they reflect Mongolia's ambition to move from resource dependence toward a knowledge-based digital society.

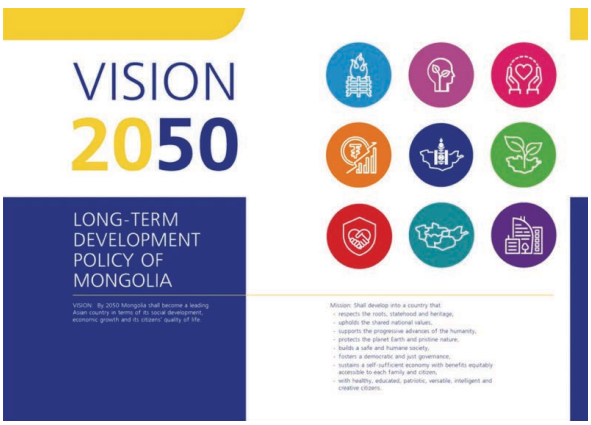

Figure 1. Vision 2050 National Development Strategy Chart

Source: Government of Mongolia(2020)

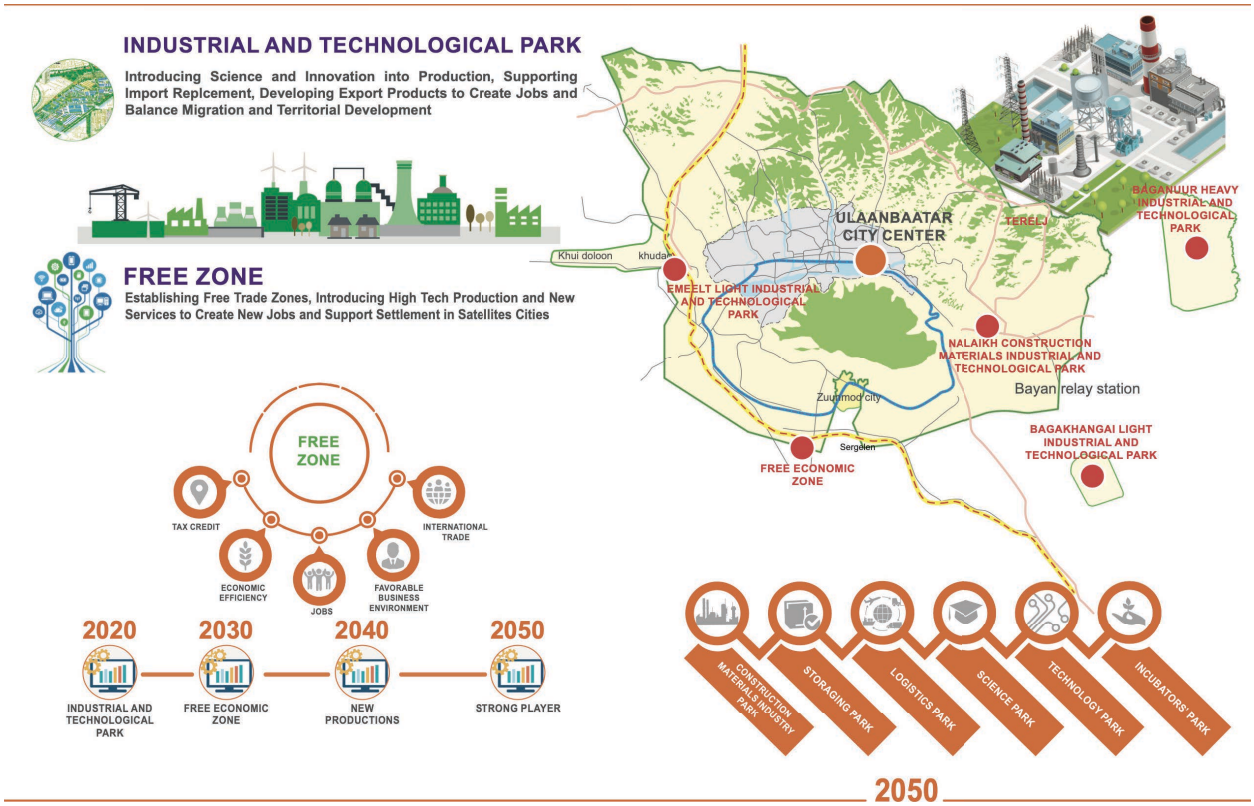

Figure 2. Industrial and Technology Parks

Source: Government of Mongolia(2020)

The concept has 6 goals: digital infrastructure, E-governance, cyber security, digital literacy, innovation, and utilization of digital products to reflect the ambition to build a knowledge- and intelligence-based digital nation (Digital Nomad IT Park, 2025).

Simultaneously, the expansion of Science, Technology, and Innovation (STI) parks has laid the foundation for a knowledge-driven economy capable of leapfrogging legacy constraints and promoting inclusive innovation, entrepreneurship, and collaboration. (UNCTAD, 2025).

Building the Digital Foundations: Smart Government and E-Mongolia

Mongolia's digital economy has expanded rapidly in recent years, driven by robust ICT sector growth. Between 2019 and 2023, ICT's nominal GDP grew an average of 19.4 percent annually, reflecting surging domestic demand and coordinated public–private investment. The country's ICT Development Index has also continued to improve, rising from 85.9 in 2023 to 87.0 in 2024, surpassing the Asia-Pacific regional average of 77.3 (Figure 3).

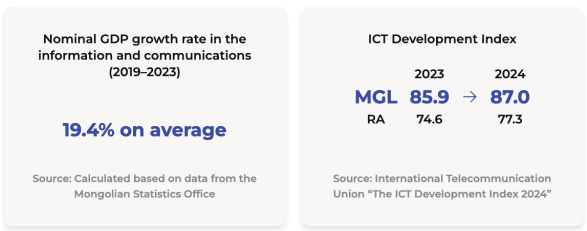

Figure 3. Mongolia's ICT Growth Indicators

Source: National Information Technology Park(2024)

Ulaanbaatar's digital transformation follows a four-pronged strategy: the Smart Government Project as the digital infrastructure backbone, the E-Mongolia platform as a citizen service portal, the E-Business platform as an enterprise service hub, and STI parks as incubators for innovation. This approach ensures that modernization extends beyond technology adoption to institutional strengthening and cross-sector collaboration.

The Smart Government Project (2015–2021), financed with USD 17.8 million from the World Bank, established the backbone of Mongolia's digital governance. Key outcomes included the Government Integrated Data Center, National Enterprise Architecture, and Open Data Portal, along with training for over 1,200 civil servants and interconnection of more than 60 systems across ministries (World Bank, 2022). These efforts built human capacity and ensured digitalization became an internal public-sector competency rather than an outsourced process. Without this groundwork, later platforms like E-Mongolia could not have scaled securely or interoperably.

E-Mongolia, launched in October 2020 by the Communications and Information Technology Authority (CITA), transformed citizen services by unifying more than 1,200 services from 87 institutions into one interface. Within five months, the platform reached one million users. As of April 24, 2025, it had grown to two million registered users, approximately 88 percent of Mongolia's adult population (E-Mongolia, 2025). This rapid adoption illustrates public trust in digital services and a growing expectation of convenience from government interactions.

Complementing this, the government launched the E-Business platform in 2023, digitized enterprise registration, licensing, and regulation. Within its first year, 6,717 new businesses were created, with 33,750 daily active users (Bilgunn, 2024). By simplifying startup formation, the platform lowered entry barriers and encouraged SME formalization, a crucial step for economic diversification. Together, E-Mongolia and E-Business form a dual-track model: one citizen-oriented, the other enterprise-oriented, both reinforcing transparency, efficiency, and innovation. This holistic design positions Ulaanbaatar as a prototype for integrated digital governance in developing contexts.

Expanding Digital Finance: Ulaanbaatar's Fintech Emergence

Fintech Growth Drivers

Historically, Mongolia's vast territory and sparse population limited banking access. These constraints opened opportunities for fintech to leapfrog physical infrastructure, offering digital alternatives for inclusion (Yang & Jung, 2024).

In recent years, rising internet penetration has accelerated this shift. By 2024, internet usage reached 83.9 percent, or 2.91 million people, while mobile connectivity stood at 147.8 percent, equivalent to 5.13 million cellular connections (Kemp, 2024). Such connectivity provided fertile ground for digital payment adoption and mobile-first innovation centered in Ulaanbaatar. The capital has since emerged as Mongolia's leading fintech hub, a space where finance, technology, and entrepreneurship converge.

Financial Reforms in Ulaanbaatar

Although banks still dominate in size and profit, fintech firms in Ulaanbaatar now grow faster and record higher returns on assets and profit margins (Inside Mongolia, 2023). This signals not only competition but an ongoing redefinition of financial service delivery.

As Mongolia's financial and tech hub, Ulaanbaatar leads implementation of the National Payment System Strategy (2022–2026), which aims to make most payments digital within five years (Bank of Mongolia, 2023a).

- Payment System Modernization Project and Real-Time Gross Settlement (RTGS) upgrades (2016–2017)
- Introduction of Europay, MasterCard, and Visa (EMV) and Near Field Communication (NFC) cards (2019–2020)
- Cybersecurity and tokenization reforms with a central depository (by 2023) (Figure 4).

Together, these reforms built a regulatory environment encouraging experimentation through sandboxes and

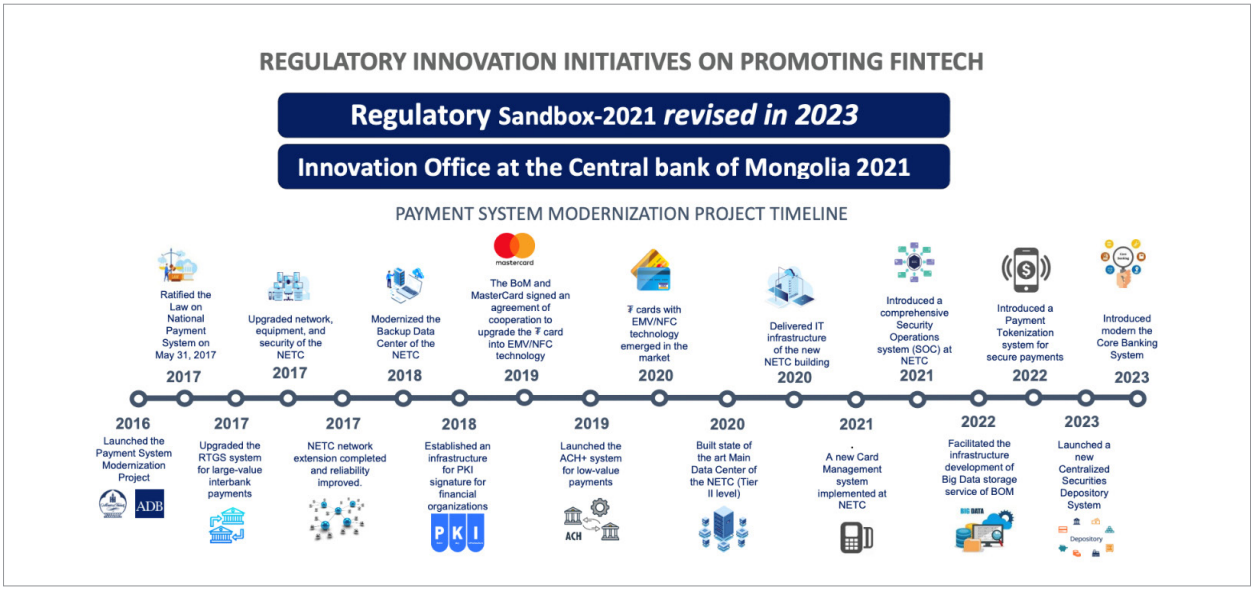

Figure 4. Timeline of Mongolia's Fintech Policy Reforms

Source: Bank of Mongolia(2023)

innovation offices while fostering trust between fintech firms, banks, and regulators (Bank of Mongolia, 2023b).

In 2023, Mongolia became the first Asia-Pacific country to meet all 40 FATF recommendations, signaling a decade-long journey from its 2013 "grey-list" status (Montsame, 2023). The Financial Information Unit of Mongolia also strengthened its international collaboration through the Egmont Group to improve AML/CFT data exchange and transparency (Financial Information Unit of Mongolia, 2023). Ulaanbaatar not only secured a symbolic leadership position that enhanced its credibility as a trustworthy digital finance hub but also positioned itself as a partner of choice for cross-border fintech services, including QR payment interoperability, remittance platforms, and BNPL merchant partnerships, while paving the way for its digital identity and payment systems to align with standards in Korea, Japan, and ASEAN. The reforms strengthened resilience and stability, key factors that enhance its appeal to international investors, and Ulaanbaatar's reputation as a Vision 2050 finance hub (Figure 5).

International indicator	MONGOLIA	Kazakhstan	Uzbekistan	Kyrgyzstan	Indonesia	Singapore
Democracy Index (2023, out of 10)	**6.48**	3.08	2.12	3.7	6.53	6.18
Telecommunications Infrastructure Index (2022, maximum 1)	**0.69**	0.75	0.65	0.66	0.63	0.87
Human Capital Index (2022, maximum 1)	**0.83**	0.9	0.77	0.81	0.74	0.9
World Risk Index (2023, up to 100)	**2.11**	2.15	1.52	2.42	43.5	0.63

ources: Economist Democracy Index 2023, UN E-Government Knowledge base, Ruhr University Bochum IFHV WorldRisk Report 2023

Figure 5. Mongolia's Attractiveness as an Investment Destination

Source: National Information Technology Park(2024)

As the digital ecosystem matured, cybersecurity became a new frontier. Ranked Tier 3 out of 5 in the ITU Global Security Index with a score of 56 (International Telecommunication Union, 2024) and the country aims to raise this by 25 points within two years, which would move Mongolia into Tier 2 ("Advancing") status (Figure 6) (Montsame, 2025). Plans include stronger monitoring and security audits, deepening participation in international cyber drills, and expanding professional training to address the shortage of skilled experts (Digital Watch Observatory, 2022). Concentrating these efforts in Ulaanbaatar ensures protection of the nation's key data and financial infrastructure, reinforcing public trust in the digital transition.

Nurturing Innovation: STI Parks and Entrepreneurial Ecosystems

While Mongolia's national policy frameworks created suitable conditions for development, Ulaanbaatar has emerged as the operational hub of the country's startup ecosystem and fintech expansion. Institutions such as the Ulaanbaatar Innovation Hub, Socratus Startup Studio, and the National IT Park serve as incubators and accelerators, offering mentorship, seed funding, and access to a global network. These organizations transform policy into tangible innovation, connecting research with commercialization.

Supported by the 2025 National AI Strategy and the E-Business Platform, these institutions have facilitated the creation of over 6,000 startups and processed more than 118,000 digital transactions (Bilguun, 2024). This surge demonstrates the city's emergence as a genuine innovation engine rather than a passive policy implementer.

The ecosystem's momentum is backed by measurable progress. The transformation of Ulaanbaatar has boosted Mongolia to advance in the Startup Blink Global

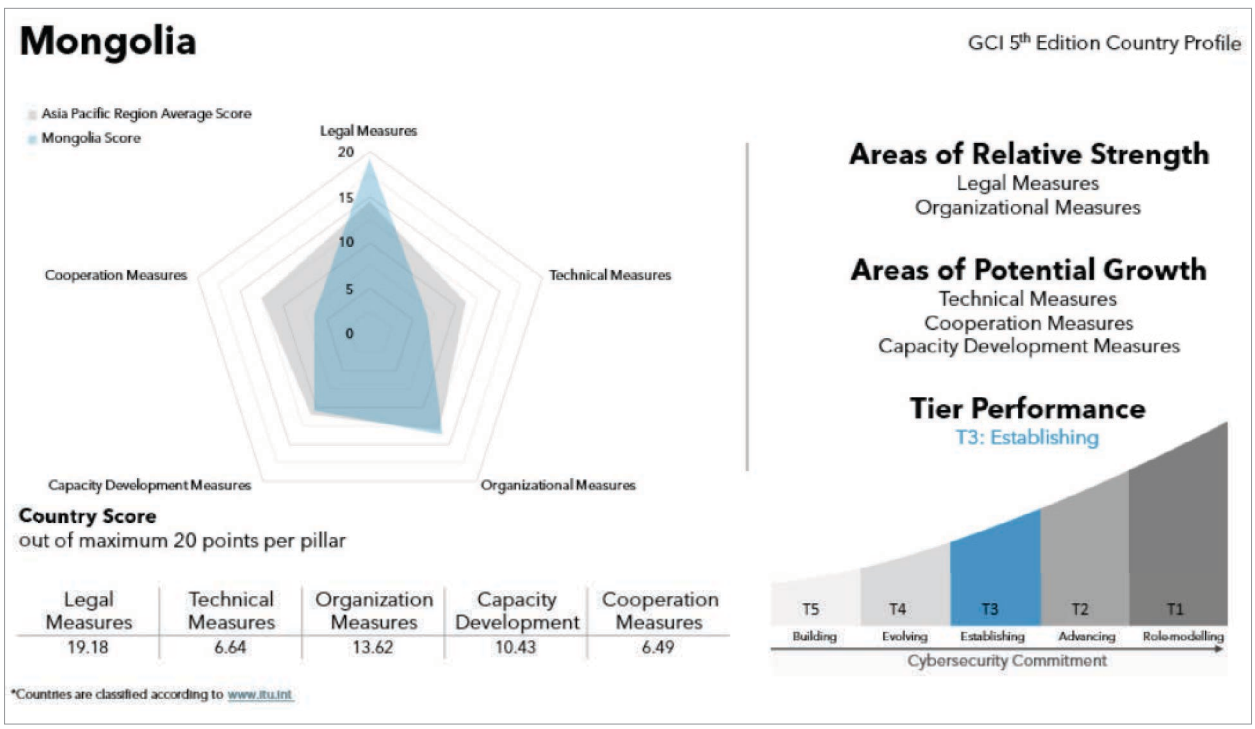

Figure 6. Mongolia's Cybersecurity Performance in the Global Cybersecurity Index

Source: International Telecommunication Union (2024)

Startup Ecosystem Index, moving from 93rd in 2020 to 81st in 2024. Human capital is central to this growth, with 36 percent of startup founders holding a master's degree or higher, underscoring the intellectual base driving entrepreneurship. A study by Mongolia Startup Ecosystem Baseline Survey (START) estimated the combined valuation of 91 surveyed startups at USD 130 million, although most remain at the seed or early stage (Figure 7) (National Information Technology Park, 2024). These numbers show not just startup quantity but the growing depth of Mongolia's innovation capacity.

Figure 7. Mongolia's Startup Ecosystem Growth and Valuation

Source: National Information Technology Park(2024)

Within this landscape, Socratus Startup Studio alone has evaluated more than 600 startup applications and invested MNT 5 billion (approximately USD 1.4 million) in 23 ventures spanning artificial intelligence, digital wallets, mobile lending, and cross-border payment systems (Socratus Startup Studio, 2023). This steady capital flow ensures that domestic startups become investment-ready for international partnerships, linking Mongolia's local innovation with global finance. Through such activities, Ulaanbaatar's STI parks now function as the backbone of Mongolia's fintech and entrepreneurial ecosystem.

Measuring the Impact: Economic, Social, and Global Outcomes

Economic Gains

Ulaanbaatar's fintech ecosystem has created new channels of capital flow that strengthen both the city's economy and national financial inclusion. One example is LendMN, a pioneering digital lending platform to become the first fintech to IPO on the Mongolian Stock Exchange. In addition to processing more than 600 loan applications each day, the company disburses over USD 70 million in funding to microenterprises and small businesses (LendMN, 2024). In 2025, LendMN secured a USD 20 million debt facility to expand access to finance for underserved populations, further cementing its role as a leader in the digital economy (Fintech Weekly, 2025). These milestones illustrate how fintech can directly empower SMEs, a sector critical for job creation and inclusive growth.

Storepay is another leading fintech success story emerging from Ulaanbaatar's STI ecosystem. Mongolia's first and largest Buy Now, Pay Later (BNPL) service is a pioneering fintech innovation that accelerates Ulaanbaatar's digital economy. Storepay, founded in 2019, offers interest-free installment payments and has revolutionized consumer credit access by pioneering a fully digital model. As of April 2024, Storepay has facilitated over 1.09 million total purchases and processed more than MNT 372 billion (approximately USD 104 million) in transaction volume (Storepay, 2024). The platform now boasts over 516,000 registered users, including 235,000 active users, and collaborates with 4,792 merchants nationwide, 90% of major mall retailers, hospital and service industry businesses in Ulaanbaatar accept Storepay, and the data shows that participating merchants have experienced an average sales boost of over 15%. On average, there are 750 or more daily transactions conducted through the app. Most notably, Storepay has helped its customers save over MNT 34 billion (approximately USD 9.5 million) in financing costs, while contributing MNT 4.5 billion (approximately USD 1.3 million) to the national tax revenue (Storepay, 2024). Such outcomes demonstrate how fintech advances not only financial convenience but also fiscal contribution and urban productivity.

Social Transformation

Digitalization has generated substantial measurable benefits. The government saves an estimated USD 30 million annually in administrative costs through the

digitization of public services (Urbanet, 2022). A CITA survey (2023) reported a 40-percent increase in citizen satisfaction, due to reduced bureaucracy and improved transparency. Beyond efficiency, these changes reinforce public trust, a vital currency for sustaining future reforms.

Global Recognition

Internationally, Mongolia has climbed 28 ranks in the UN E-Government Development Index between 2021 and 2023, entering the "Very High" category, a direct outcome of reforms piloted in Ulaanbaatar. Its model has attracted interest from countries like Bhutan, which see its relevance in similarly challenging geographic and demographic contexts and have explicitly sought to learn from Mongolia's experience in scaling citizen-focused e-government solutions. (Inside Mongolia, 2025). Ulaanbaatar's initiatives also earned the Global Government Excellence Award and Open Government Award (2023) (Montsame, 2024). Meanwhile, Mongolia's improved in the Global Innovation Index (GII) score, which is now classified as an "innovation overperformer" relative to its income level and recognized by World Intellectual Property Organization (WIPO) as "performing above expectations for its level of development" (Figure 8). The city is generating more innovation outputs than would be expected based on input metrics like R&D spending WIPO (2024). These recognitions enhance not only national pride but also international investor confidence, reinforcing Mongolia's image as a credible emerging innovation hub.

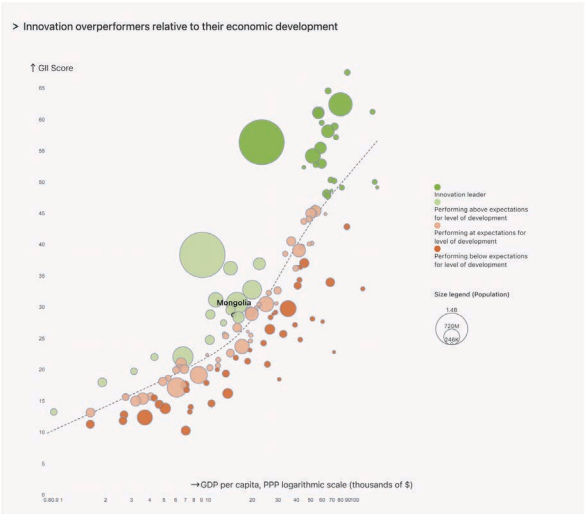

Figure 8. Mongolia's Innovation Performance in the Global Innovation Index 2024
Source: World Intellectual Property Organization (WIPO)

Conclusion

Ulaanbaatar's transformation reveals how digital innovation, when aligned with national strategy, can reshape governance and growth trajectories. Guided by Mongolia's Vision 2050 and the Digital Nation Roadmap, the city has become a testing ground for institutional modernization, smart service delivery and fintech integration. Platforms like E-Mongolia and E-Business, combined with regulatory innovation and startup support, have redefined how citizens, businesses, and government interact in daily life.

Several lessons emerge from Mongolia's experience. Integrating digital goals within a long-term national strategy ensures continuity and alignment across ministries. The presence of a dedicated implementation body such as the Communications and Information Technology Authority has improved cross-sector coordination and technical execution. The prioritization of interoperability between services, from identity to payments, has enhanced both user convenience and administrative efficiency. In addition, Mongolia's phased regulatory approach has helped fintech scale while maintaining compliance with international standards.

Despite this progress, ongoing challenges include extending digital access to rural provinces, strengthening cybersecurity systems, and cultivating a skilled digital workforce. Continued investment in infrastructure, training, and inclusive policy design will be essential. Still, Ulaanbaatar's progress offers a compelling model for other emerging economies. Its approach demonstrates how digital transformation can deliver not only technological upgrades but also institutional resilience, improved governance, and more equitable urban development.

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08

Dubai, United Arab Emirates

Dubai Autonomous Driving Technology Adoption Strategy and Policy Implications

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Abstract

Dubai stands as one of the world's leading cities in autonomous mobility adoption. Through the Dubai Autonomous Transportation Strategy, the city aims to achieve a 25% conversion of all trips into autonomous modes by 2030. Partnering with global companies such as WeRide, Pony.ai, and Joby Aviation (with earlier pilot testing by GM Cruise), Dubai has implemented pilot projects across road, maritime, and aerial domains, emphasizing citizen-centered trials and institutional readiness over domestic technology development. This approach, aligned with the Dubai Clean Energy Strategy 2050 and the Dubai 2040 Urban Master Plan, advances sustainability and smart city transformation. Dubai's experience demonstrates that even cities with limited R&D capacity can lead autonomous mobility transitions through pilot-oriented governance, proactive regulation, and international collaboration. The integration of technology deployment, regulatory frameworks, and public trust emerges as a critical foundation for building sustainable and inclusive urban transport ecosystems.

Keywords **Autonomous Driving Policy, Dubai Autonomous Driving Strategy, Future Mobility, Smart Mobility, Autonomous Transport System**

1. Introduction

Dubai is a rapidly expanding global city, facing increasing vehicle dependency, congestion, and environmental pressures. In response, the government introduced *the Dubai Autonomous Transportation Strategy* (2016), aiming to convert 25% of all transportation trips into autonomous modes by 2030 (Government of Dubai, 2016).

Rather than emphasizing domestic technology development, Dubai has focused on technology adoption and deployment, reflecting limited in-house R&D capacity and a broader policy orientation toward becoming a net-zero carbon city, promoting smart city transformation, and enhancing urban efficiency through innovation (Government of Dubai, 2015; Dubai Supreme Council of Energy, 2023). This approach also aligns with broader global findings that citizens' acceptance and institutional readiness are decisive factors in the successful diffusion of autonomous mobility (Al Shamsi, 2020; Cho et al., 2023). Through partnerships with global players such as WeRide, Pony.ai, and Joby Aviation, Dubai positions itself as a city-scale testbed where cutting-edge mobility solutions are deployed and directly experienced by citizens. Several Chinese autonomous mobility firms, including WeRide and Pony.ai, have identified Dubai and Saudi cities as Gulf-region bases for commercialization between 2025 and 2026 (Reuters, 2025).

This adoption-oriented model aligns with the *Dubai Clean Energy Strategy 2050 and the Dubai 2040 Urban Master Plan*, which jointly emphasize sustainability, digital transformation, and integrated governance (Government of Dubai, 2015). The following section explains how Dubai's institutional readiness, regulatory frameworks, and pilot programs across road, maritime, and aerial domains operationalize this vision.

2. Dubai's Autonomous Driving Strategy and Implementation

2.1 Institutional Framework: The Role of

the Roads and Transport Authority (RTA)

The Roads and Transport Authority (RTA), established under Law No. 17 of 2005, is the principal government body responsible for transportation planning, regulation, and infrastructure integration in Dubai (RTA, 2022). The RTA manages partnerships with private operators, oversees vehicle licensing, and enforces operational standards. Under Law No. 9 of 2023, the RTA gained explicit authority to regulate autonomous vehicle operations, including licensing, route designation, safety compliance, and data oversight (Government of Dubai, 2023). This institutional framework enables a controlled yet innovative environment for piloting autonomous mobility.

2.2 Strategic Overview

According to official documentation, the strategy aims to reduce transportation costs by 44%, decrease traffic accidents and carbon emissions by 12%, improve individual productivity by 13%, and save roughly 396 million hours of travel annually (Government of Dubai, 2016). Its objectives include: (1) rapid adoption of global technologies through partnerships, (2) citizen-centered pilot programs, (3) integration of governance, infrastructure, and user engagement, and (4) advancement of sustainable urban mobility.

2.3 Implementation Across Three Domains

2.3.1 Road – Robotaxis

GM Cruise: Dubai's RTA and Cruise began supervised autonomous testing in the Jumeirah-1 area in 2023 under a government permit (Government of Dubai, 2023). However, following GM's 2024–2025 corporate restructuring and regulatory reviews, Cruise's full-scale robotaxi rollout in Dubai remains pending and uncertain (AP News, 2024; WIRED, 2024).

WeRide: In collaboration with RTA and Uber, WeRide is preparing a pilot robotaxi launch by late 2025, targeting full commercialization in 2026. This follows the firm's earlier pilot trials in Abu Dhabi, now being extended to Dubai (WeRide, 2025; U.S. Department of Commerce, 2025).

Strategic Goal: Dubai aims to operate approximately 4,000 autonomous taxis by 2030, covering 25% of the city's total traffic volume, as specified in the Dubai Autonomous Transportation Strategy (2016) (Government of Dubai, 2016).

Figure 1. GM Cruise robotaxi (CNN, 2023).

Figure 2. WeRide's fully driverless robotaxi trial operations (WeRide, 2025).

2.3.2 Maritime – Autonomous Abra

Technology & Operations: Traditional wooden abras (water taxis) have been retrofitted into electric Level-4 autonomous vessels. These boats use GPS, radar, and multiple onboard sensors to maintain routes, while a captain supervises safety during operation (Khaleej Times, 2023; Roads and Transport Authority [RTA], 2022).

Service Experience: The autonomous abra offers quiet, zero-emission rides for citizens and tourists. The service is currently limited to select routes along Dubai Creek, with plans for gradual expansion following successful pilot evaluation (Khaleej Times, 2023).

Figure 3. Now, driverless abras in Dubai (Khaleej Times, 2023).

Figure 4. Dubai to be world's first flying taxi city (Time Out Dubai, 2025).

2.3.3 Aerial – Vertiport-Based Air Taxis

Urban Air Mobility (UAM): Dubai is developing vertiport-based air taxi services using eVTOL aircraft to connect Dubai International Airport and Downtown Dubai (Reuters, 2025; Government of Dubai, 2023).

Global Partnerships: This project/program is implemented through collaborations with Joby Aviation (USA) and Skyports (UK) under the supervision of the RTA and the Dubai Civil Aviation Authority (Reuters, 2025).

Timeline & Impact: Infrastructure construction and test flights are ongoing, with full commercial operations targeted for 2026. Recent route studies indicate that the 12-minute DXB–Downtown trip by eVTOL may save over 70% of travel time compared to the average 45-minute trip by car (Reuters, 2025).

3. Policy Implications

Dubai's experience demonstrates that a pilot-oriented, city-led approach can accelerate autonomous driving adoption even in regions with limited domestic capabilities. Recent developments further highlight ongoing efforts:

3.1 Regulatory and Institutional Readiness

Law No. 9 of 2023 provides a comprehensive legal framework for the licensing and operation of autonomous vehicles in Dubai, addressing operator permits, technical standards, safety, insurance, and liability (Government of Dubai, 2023; Norton Rose Fulbright, 2023). The RTA is empowered to issue licenses, designate testing zones, and monitor compliance.

3.2 Citizen-Centered Design and Public Trust

Pilot programs allow citizens to experience autonomous mobility in real-world contexts, fostering awareness and public trust. Transparent publication of safety data and user feedback mechanisms have strengthened public confidence (Government of Dubai, 2023).

These findings are consistent with regional studies showing that perceived safety, transparency, and service reliability significantly influence user acceptance of autonomous vehicles (Al Shamsi, 2020; Lee et al., 2024; Park, 2023).

3.3 Global Partnerships and Innovation Ecosystem

By collaborating with multiple international technology providers instead of relying on a single firm, Dubai has cultivated a diversified innovation ecosystem that enhances resilience and accelerates commercialization (U.S. Department of Commerce, 2025).

3.4 Governance Integration for Sustainability

The integration of infrastructure investment, regulatory oversight, and citizen engagement reflects a systemic governance model that supports the emirate's broader net-zero and smart city ambitions (Government of Dubai, 2015; Dubai Supreme Council of Energy, 2023).

Comparative analyses from Seoul and other smart city cases further indicate that institutional coordination and continuous pilot governance are critical for sustainable autonomous transport ecosystems (Jo et al., 2023; KOTRA, 2023).

Conclusion

Through these measures, Dubai's demonstrate that adoption-led innovation, grounded in institutional capacity, regulatory foresight, citizen participation, and international collaboration, can compensate for limited domestic R&D capability. Rather than comparing technology development and adoption, Dubai's case shows that focusing on structured adoption within clear governance and policy frameworks can enable sustainable and globally competitive autonomous mobility ecosystems.

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09

Mexico City, Mexico

Mexico City's Digital Health Transformation: The IMSS Digital Case

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Abstract

Mexico City's Instituto Mexicano del Seguro Social Digital (IMSS Digital) shows how a megacity can treat digital health as core urban infrastructure. The program responded to long queues, paper-based processes, and fragmented records, affecting roughly 4.2 million IMSS beneficiaries in the capital. A citywide model aligned federal services (IMSS Digital app), municipal connectivity (more than 34,000 public Wi-Fi hotspots led by the Agencia Digital de Innovación Pública (ADIP), and local hospital networks (Secretaría de Salud de la Ciudad de México [SEDESA]'s Sistema de Administración Médica e Información Hospitalaria [SAMIH] information system), creating the Western Hemisphere's first comprehensive megacity-scale digital health platform.

Measured outcomes confirm system-level impact: over 10 million app installations; more than 35 million annual digital transactions; an estimated 43% reduction in administrative counter demand; 2.8 million avoided healthcare trips each year; and household savings of approximately USD 52 million for low-income workers. During COVID-19, the architecture absorbed a surge of approximately 340% in usage without systemic failure.

Ultimately, Mexico City's experience demonstrates that technology alone was not enough. Success emerged from the intersection of governance, connectivity, and culture—ensuring identity and access at scale (Número de Seguridad Social [NSS] / Clave Única de Registro de Población [CURP]), interoperability with legacy systems, multi-level governance (IMSS–ADIP–SEDESA), universal connectivity, and cultural bridges for inclusive adoption. Taken together, these elements establish Mexico City as a model for megacities aiming to build equitable and resilient digital health systems.

Keywords Digital Health, Urban Innovation, Digital Transformation, Digital Equity, Mexico City

Introduction

The Challenge: Healthcare in a Megacity Under Pressure

By 2015, the Mexico City metropolitan area—home to more than 22 million residents—faced pressures typical of aging, chronic-disease-intensive megacities: paper-based administrative processes, fragmented health records, and long queues that reduced system efficiency and patient satisfaction (INEGI, 2021; Harbering & Schlüter, 2020). Baseline evidence also showed uneven digital culture and e-government adoption across income and age groups, shaping timing and policy design (CIDE, 2023; IDB, 2022).

For the approximately 4.2 million beneficiaries of the Instituto Mexicano del Seguro Social (IMSS) in Mexico City (about 20% of the city's population and 13% of all national IMSS beneficiaries),routine procedures such as entitlement verification or clinic reassignment could consume an entire workday. This represented losses of roughly USD 18 in wages and USD 1 in transit for low-income workers (IMSS Statistical Division, 2024; Mexico City Labor Observatory, 2019).

Given the dense IMSS footprint and the rapidly expanding smartphone penetration combined with the rollout of more than 30,000 public Wi-Fi hotspots, a digital front door for high-volume, low-complexity transactions offered the highest policy leverage to alleviate bottlenecks and improve healthcare access in Mexico City.

The Digital Response: IMSS Digital as Critical Urban Infrastructure

Launched on November 30, 2015, IMSS Digital reimagined public health interactions for more than 22 million Mexico City residents and quickly became Mexico's most-downloaded federal government app (IMSS, 2015). Its early success reflected favorable timing—city investments in connectivity during the Mancera administration, IMSS's modernization push following near-bankruptcy warnings in 2012, and urban smartphone penetration of 67% that enabled mass uptake (IDB, 2022; OECD, 2019; IFT, 2016). Mexico City was deliberately chosen as a digital health laboratory given IMSS's densest footprint (32 hospitals and 183 family medicine units), a comparatively educated user base, and high political visibility (IMSS Infrastructure Atlas, 2024; SEDESA, 2020). A strong outcome promised a scalable template for 35 state delegations and 70+ million beneficiaries, whereas failure risked undermining public trust in national e-government efforts (National Digital Strategy Office, 2021).

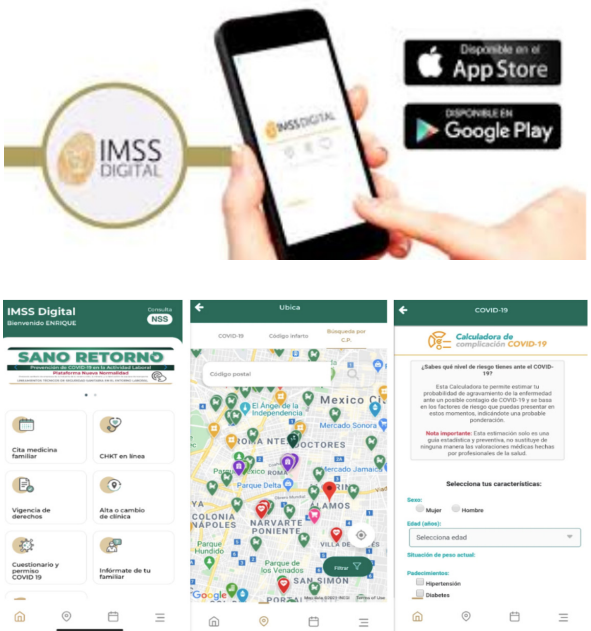

Figure 1. IMSS Digital App: User Interface on iOS and Android

Organization and Operation in Practice

IMSS Digital emerged from a Directorate-General mandate that aligned three core areas—Incorporation & Collection, Medical Benefits, and Innovation & Technology—to deliver integrated, citizen-facing services and to break long-standing silos (IMSS, 2017). The program set a clear operational target: simplify the 23 highest-demand procedures and digitize 18 by 2017, informed by an early Mexico City beta (~2,000 users) that refined interface flows and back-office routing (IMSS Innovation Division, 2016).

IMSS Digital Architecture: Channels, Core Systems, and Change Management

IMSS Digital was built on three interconnected pillars that enabled mass adoption. On the citizen-facing side, the multi-channel ecosystem—mobile apps for iOS and Android, a web portal, and a toll-free line (800-623-2323)—concentrated the highest-volume interactions, including appointment scheduling, entitlement verification, clinic assignments, and access to basic directories (IMSS, 2018). This front end was supported by a robust operational backbone that integrated the national beneficiary registry (BDNSS) in real time, automated clinic assignments based on residential address, and initiated the gradual consolidation of electronic health records to ensure continuity of care (IMSS Technology Integration Office, 2018). Finally, change management was sequenced strategically: high-demand, low-complexity services such as entitlement checks and clinic assignments were digitized first, followed by more complex processes like referrals. Adoption campaigns leveraged everyday settings—public transport, community health centers, and free Wi-Fi zones—to position digital channels as the preferred entry point into the health system (Mexico City Marketing Research Institute, 2017).

As shown in Figure 2, mobile applications became the dominant access channel, accounting for 55% of interactions, while public Wi-Fi use (20%) highlights the equity dimension of the strategy, ensuring access for populations without private data plans.

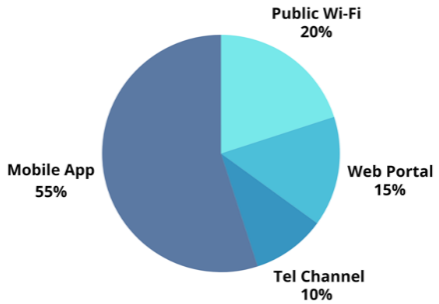

Figure 2. Distribution of User Channels for IMSS Digital in Mexico City

User Experience Journey: A Day in Digital Healthcare

IMSS Digital transformed what once required an entire workday into a task completed in minutes over public Wi-Fi. In December 2018, for example, a routine clinic change that had previously cost a worker about USD 18 in lost wages and USD 1 in transit—plus hours in line—was completed in just seven minutes. For many, this marked their first interaction with e-government services (UNAM, 2018–2022).

The process was straightforward: users verified their identity with NSS or CURP, selected the required service, received real-time processing for appointments or clinic changes, and downloaded a digital confirmation with a QR code. By 2021, this pattern had become standard across the metropolitan area, with individuals completing an average of 23 digital actions per year. At scale, these small savings translated into approximately USD 375–380 per person annually, a substantial benefit for the city's low-income workforce (UNAM, 2022).

Measurable and Observable Outcomes

Since its launch in November 2015, IMSS Digital has recorded adoption rates that exceeded all projections. Within six months, it became the most downloaded federal government app in Mexico, and by 2025 the Android version alone surpassed 10 million installations, with an estimated 1.7 million active users concentrated in the Mexico City metropolitan area (Google Play Store Analytics, 2025; IMSS CDMX, 2023).

Transaction data confirm that adoption translated into sustained use. By late 2018, users had executed ~17 million digital transactions, including ~6 million appointment requests. The growth continued through the pandemic: in 2024, the system processed 35M+ annual entitlement verifications, making this single function the most heavily used digital health service in Mexico (IMSS, 2018; IMSS, 2025).

Mexico City–specific indicators demonstrate the depth of transformation. Digital appointment completion rates reached 89%, well above the national average of 76%. Average wait times in family medicine units fell from 34 to 12 minutes, while in-person administrative demand dropped by 43% between 2019 and 2021. By 2023, two-thirds (67%) of IMSS beneficiaries in Mexico City had used at least one digital service, highlighting the widespread penetration and system-level efficiency gains (Mexico City Digital Health Performance Assessment, 2021).

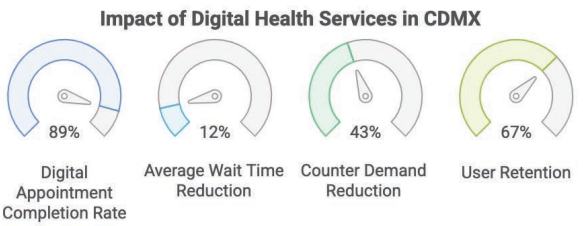

Figure 3. Key digital health performance metrics for IMSS in Mexico City

Integrated Ecosystem, Resilience Stories, and Urban Impacts

Mexico City's digital health transformation rests on two coordinated institutional tracks that operate as a single ecosystem. At the local level, SEDESA's SAMIH digitalized all 31 city-run hospitals, achieving citywide electronic records and processing nearly two million visits in its first three years while modernizing clinical and IT workflows (SEDESA, 2017; The CIU, 2021). At the federal level, IMSS Digital scaled access across hundreds of facilities. Together—with municipal connectivity provided by more

than 34,000 free Wi-Fi hotspots led by ADIP—these capabilities formed a comprehensive urban digital-health platform in which, by 2024, an estimated 78% of users connected via public Wi-Fi, expanding access regardless of data-plan affordability (Guinness World Records, 2021; ADIP, 2021; ADIP, 2024). Their governance alignment is summarized in Figure 4, which depicts the three-tier integration (federal–municipal–local) that underpins metropolitan-scale operations.

Implementation experience shows that resilience and cultural adaptation were as decisive as technology. In March 2016, a 67% flu-season surge triggered a six-hour outage at a Mexico City clinic; the response—server capacity expansion and a backup phone line—later enabled the platform to absorb a ~340% demand spike during the March 2020 lockdown without collapse (IMSS Crisis Management Archive, 2016; IMSS Pandemic Response Unit, 2020). Cultural dynamics also mattered: beginning in 2019, the "Abuela Digital" pattern—older adults booking services for relatives—led to a family-management feature now used by 1.8 million accounts, illustrating how design choices can bridge the digital divide and broaden inclusive adoption (IMSS UX Research Division, 2020).

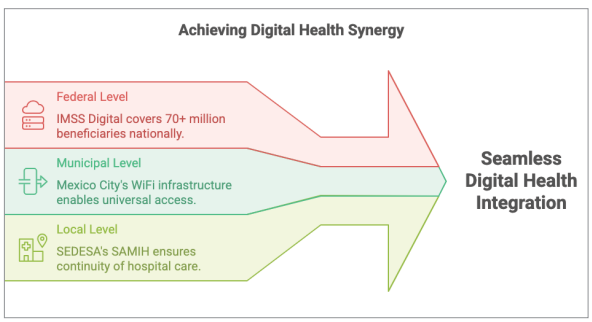

Figure 4. Three-Tier Institutional Integration Model for Seamless Digital Health in Mexico City

City-level impacts are visible in mobility, household economics, and operational efficiency. By 2022, the system eliminated an estimated 2.8 million healthcare-related trips per year—about 340,000 fewer public-transit rides—in a city that averages 47-minute commutes each way (Mexico City Transportation Authority, 2022). These time savings translate into approximately USD 9.2 million annually among low-income workers, with disproportionate benefits for the informal labor force (57% of the market) that typically lacks paid sick leave (IMCO, 2023). Digitally enabled workflows reduced administrative counter demand and supported real-time coordination such as ambulance deployment and hospital capacity planning through interoperability between IMSS and SAMIH (SEDESA, 2022).

What distinguishes Mexico City globally is the combination of scale and integration: unlike smaller cities such as Copenhagen or Singapore, the metropolis implemented a megacity-wide system for more than 22 million residents, posing governance and technical challenges that are not easily replicable in smaller contexts. Even so, lessons on governance, connectivity, and cultural adaptation remain transferable to other large urban systems aiming for equitable digital health (WHO Digital Health Observatory, 2023; PAHO, 2022).

Integrated Governance, Cultural Bridges, and Equity Outcomes

Mexico City's IMSS Digital illustrates how digital health can serve as urban infrastructure when governance, technology, and cultural adaptation converge. The program stands out for its unprecedented three-tier coordination among federal (IMSS), municipal (ADIP), and local health (SEDESA) institutions, an arrangement rarely achieved even in smaller cities. Adoption strategies emphasized cultural adaptation—such as multi-generational households managing appointments collectively and hybrid assistance combining digital and in-person support—while universal access was secured through the world's largest free Wi-Fi network. These measures allowed IMSS Digital to become the first Latin American government app to achieve mass adoption across income groups (PAHO, 2022; UNAM, 2022; WHO, 2023).

The results confirm both efficiency and equity gains. In Mexico City, the platform prevents an estimated 2.3 million lost workdays annually, generating household savings of about USD 52 million for low-income workers, while its

resilient architecture absorbed a 340% surge in demand during COVID-19 without systemic collapse (IMCO, 2023; ECDC, 2021). Yet one-third of beneficiaries—around 1.4 million people—remain digitally excluded, underscoring the need for targeted literacy programs, simplified authentication, and accessibility for older adults and people with disabilities. Publishing Mexico City–specific KPIs and aligning interoperability standards would further strengthen performance. Taken together, the case shows that digital health can enhance both efficiency and equity when treated as a shared public good, offering a realistic policy blueprint for other large urban systems.

Conclusion

Mexico City's IMSS Digital shows how a megacity can treat digital health as core urban infrastructure rather than a convenience layer. Evidence from 2015–2024 indicates durable adoption and operations at scale, with measurable mobility and equity gains (IMSS, 2018; IMSS, 2025; ADIP, 2024).

Success factors

1. Identity & access at scale (NSS/CURP) that reduce friction at the first mile.
2. Interoperability with legacy systems via shared catalogues/APIs, enabling referrals and continuity (IMSS Technology Integration Office, 2018).
3. Governance alignment across federal (IMSS), municipal (– ADIP), and local hospital networks (SEDESA) through formal committees and data-sharing agreements (PAHO, 2022).
4. Connectivity as public-health infrastructure (34,000+ public Wi-Fi hotspots), turning "ability to connect" into an equity lever (ADIP, 2024; WHO, 2023).
5. Cultural bridges, not tech imposition: multi-generational use, hybrid assistance (digital + in-person), campaigns emphasizing time/wage savings (UNAM, 2022).

Urban impacts

- **Improved administrative efficiency**: ~43% drop in administrative counter demand, freeing capacity for clinical care (IMSS CDMX, 2023).
- **Reduced travel burden:** ~2.8 million healthcare trips avoided per year; faster access in a congested metropolis (Mexico City Transportation Authority, 2022).
- **Household financial benefits:** ≈ USD 52 million saved annually among low-income workers through avoided travel and lost wages (IMCO, 2023).
- **Crisis resilience**: absorbed ~340% usage surges during COVID-19 without systemic failure (ECDC, 2021; IMSS Pandemic Response Unit (PRU); 2020).

Despite these achievements, one-third of beneficiaries—around 1.4 million people—remain excluded from digital use. Closing this gap requires targeted literacy programs, reduced authentication barriers, and expanded accessibility for older adults and people with disabilities. Publishing Mexico City–specific KPIs and aligning data standards would further institutionalize performance monitoring and equity goals (OECD, 2019; SEDESA, 2022).

Taken together, the Mexico City case shows that digital health can advance both efficiency and equity when it is treated as a shared public good. For other megacities, the lesson is not that the model can be copied wholesale, but that governance alignment, connectivity, and cultural adaptation form a transferable blueprint for inclusive and resilient digital health.

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10

Singapore

Three Key Assets of Singapore's Startup Ecosystem

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Abstract

This study examines the conditions that have enabled Singapore to foster unicorn companies and draws corresponding policy implications. Singapore's resources are categorized into economic, physical, and network domains, revealing three salient features. First, institutions possess strong capabilities for translating research into commercial applications. Second, the city functions as a living testbed, accelerating the adoption and refinement of emerging technologies. Third, public-private networks are highly interconnected, enabling coordinated action. These elements do not operate in isolation; rather, the ecosystem functions most effectively when the three resource domains interact organically in a mutually reinforcing manner.

Keywords Startup, Unicorn, Singapore, Entrepreneur

The dynamism of Singapore's startup ecosystem

Singapore's startup ecosystem exerts a substantial influence on the national economy, with its vibrancy directly contributing to economic growth and job creation. As of 2025, Singapore ranks second in Asia and fourth globally in terms of ecosystem performance, with an estimated value of approximately USD 184 billion[1]. A key metric for assessing ecosystem maturity is the number of unicorn companies—privately held startups valued at over USD 1 billion (KCMI, 2020). This indicator plays a decisive role in promoting economic growth, generating employment, fostering innovation, attracting investment, and drawing talent. The success of unicorns sends positive signals to other startups, investors, and policymakers, thereby reinforcing ecosystem development and enhancing global competitiveness[2]. As of 2025, Singapore hosts 20 unicorns, placing it among the global leaders relative to population size[3].

While the absence of unicorns and the prevalence of small enterprises are not inherently detrimental, such a structure has both advantages and limitations. On the one hand, numerous small businesses can foster close ties with local communities, enhance industrial diversity, and reduce the risks associated with large-scale investments[4]. On the other hand, an ecosystem composed solely of small enterprises is constrained in its capacity to drive national economic growth, create jobs, and catalyze industrial transformation. Business expansion is closely

1. https://startupgenome.com/library/singapores-tech-ecosystem-by-the-numbers
2. https://evolvedash.com/blog/waning-age-of-unicorns/
3. https://ff.co/unicorn-companies-2025/
4. https://fi.co/insight/the-advantages-of-a-smaller-startup-ecosystem

linked to demand growth; startups that remain small often reflect limited market size, whereas the emergence of unicorns typically signals successful market targeting. Moreover, market expansion not only propels the focal industry but also stimulates upstream and downstream sectors. For example, Coupang transformed the logistics industry in South Korea through its distinctive "Rocket Delivery" model. Similarly, the rise of unicorns extends beyond the success of individual firms to encompass the broader advancement of the entrepreneurial ecosystem.

Factors contributing to the emergence of unicorns in Singapore

To better understand how Singapore was able to create an environment that fostered the growth of numerous unicorn companies, we need a framework for analyzing Singapore's startup environment. Although Singapore is a country, its territory is similar in size to a city. Therefore, an approach that views the city as an innovation ecosystem should be adopted. This study adopts the innovation ecosystem framework proposed by the Brookings Institution (Katz & Julie, 2014). This framework assumes that all innovation regions possess economic, physical, and network resources, which in turn enables the construction of an ecosystem based on innovation.

1. Economic assets

Economic assets refer to institutions, organizations, and companies that drive, nurture, or support innovation. This includes institutions that focus on developing cutting-edge products and services and institutions that support the growth of entrepreneurs.

Among Singapore's leading institutions in advanced research and technological innovation, the Agency for Science, Technology and Research (ASTAR) stands out as a flagship organization. As a public agency, ASTAR conducts both basic and applied research across diverse domains, including life sciences, materials science, information and communications technology, and artificial intelligence. Its research infrastructure is primarily concentrated within Bio-polis and Fusionopolis, hubs designed to promote interdisciplinary collaboration.

A notable example of an ASTAR-affiliated startup that has achieved unicorn status is Lucence[5]. Founded by oncologist and researcher Dr. Min-Han Tan, Lucence traces its origins to 2011, when Dr. Tan, then leading an ASTAR research team, developed pioneering cancer diagnostic technologies, including liquid biopsy methods. The company capitalized on ASTAR's research infrastructure, extensive industry and clinical networks, initial research funding, and access to clinical samples to advance its innovations.

In 2017, Lucence formally spun off from ASTAR, transferring its core technology and intellectual property (IP) from the agency. Throughout this process, ASTAR provided active commercialization support—connecting the startup with domestic and international investors, facilitating industry partnerships, and offering strategic advisory services. Today, Lucence has successfully commercialized its ultra-sensitive liquid biopsy technology, entered both Singaporean and U.S. markets, and evolved into a global biotechnology firm with over 20 patents and numerous international partnerships.

2. Physical assets

Physical assets encompass both private and public facilities, along with infrastructure that facilitates collaboration and connectivity. Such spaces not only bring individuals together but also serve as laboratories for developing and testing new products. Singapore leverages its entire national territory—effectively a single city—as a large-scale testbed for the demonstration and commercialization of emerging technologies.

This initiative is anchored in the Smart Nation Program, the government's flagship digital innovation strategy

5. https://www.enterprisesg.gov.sg/resources/inspiring-stories/lucence

aimed at improving citizens' quality of life, generating economic opportunities, and fostering a more connected and inclusive society through technology. The program enables startups to rapidly pilot and commercialize innovations within real-world environments, thereby reducing the time from development to market adoption.

A prominent example of this approach is CleanTech Park, Singapore's first eco-friendly business park and a leading testbed for sustainable and smart city technologies. The park integrates advanced green R&D with test-bedding activities, serving as a critical platform for Singapore's transition toward becoming a sustainable city and Asia's hub for eco-friendly technology. It hosts both domestic and international enterprises and research institutions—such as DHI Water & Environment, Diamond Energy, Yingli Solar, Toray, NEWRI, and ERI@N—to create an ecosystem conducive to technology convergence and open innovation.

3. Network assets

Network assets refer to the relationships among actors within an innovation ecosystem. These connections promote and accelerate innovation through the exchange of information and ideas while strengthening collaboration. Networks can be classified as strong ties—such as deep mentoring relationships and joint research—and weak ties, including informal interactions like networking events and hackathons.

Singapore's startup ecosystem facilitates cross-sector collaboration by rapidly disseminating the latest technology trends, market intelligence, and investment opportunities. When strong and weak ties intersect, they often give rise to new partnerships and innovative ventures. Moreover, Singaporean startups benefit from global connectivity, leveraging relationships with multinational corporations, international investors, research institutions, and overseas startups to accelerate entry into global markets.

A prime example illustrating the influence of such networks is Clobotics[6], a global computer vision and artificial intelligence startup founded in 2016 by former Microsoft executives, offers solutions in wind turbine maintenance and retail data analytics. As a finalist in SLINGSHOT 2020, Clobotics expanded its network of local and international partners, refined its market-entry strategy for Singapore, and subsequently established both R&D and business operations in the country, accelerating its expansion across Asia.

Singapore encourages informal networking, facilitating relationship-building over coffee. The 'Komo Coffee Club' and 'Business Networking Mega Coffee Session' are prime examples of such informal networks. Singapore's informal networks have been instrumental in addressing the structural constraints of its startup ecosystem, particularly the limitations imposed by a small domestic market and a predominantly government-led development model. Given the restricted local demand, early-stage startups were effectively compelled to pursue international expansion from the outset. In this context, informal networks facilitated the rapid exchange of critical knowledge, including emerging market trends, access to investors, and strategies for entering overseas markets. While the Singaporean government has played an active role in supporting entrepreneurship, policy-driven initiatives alone have proven insufficient for fostering innovation and ensuring long-term ecosystem sustainability. Consequently, entrepreneurs increasingly turned to voluntary communities and informal networks as essential mechanisms for building collaborative capabilities and enhancing collective resilience.

Grab[7], a smartphone-based ride-sharing service provider in Southeast Asia leveraged relationships with global venture capital firms—formed through such networking platforms—to secure large-scale investment and expand its operations throughout Southeast Asia.

6. https://clobotics.com/

7. https://www.businessinsider.com/grab-coo-cofounder-on-growth-from-a-ride-hailing-service-to-a-super-app-2021-1?IR=T&international=true&r=US

Conclusion

This study examined the resources constituting Singapore's startup ecosystem, categorizing them into economic, physical, and network assets. Each asset type possesses distinct characteristics, and based on this analysis, several policy priorities emerge.

From an economic asset perspective, there is a need for a higher-level institution—equipped with legal, organizational, and budgetary authority—to coordinate the entire cycle encompassing research, commercialization, entrepreneurship, investment, and global expansion. However, experience indicates that merely establishing a separate institution, positioned horizontally alongside these functional domains, is insufficient to develop the specialized expertise required for translating research outcomes into commercial applications or to foster effective, practice-oriented collaboration. Singapore's approach, positioning A*STAR as a central hub bridging academia and industry, underscores that such functions cannot be expected from individual research institutions alone. Moreover, fragmenting the commercialization process across multiple bodies hampers role coordination and creates communication gaps between research and commercialization entities. Thus, this function should operate under the authority of an overarching institution, legal mandate, or integrated functional framework.

From a physical asset perspective, policy adjustments are required to fully utilize the city as a living testbed, supported by integrated safety measures, expanded citizen participation, and stronger linkages to global markets. While technology demonstrations are often confined to laboratories, pilot facilities, or designated testbeds, certain innovations demand broader environments. In such cases, existing legal and institutional frameworks may be inadequate, particularly in urban settings where public safety and community concerns must be addressed. Therefore, a structured deliberation platform involving citizens and multidisciplinary experts is essential to ensure the effective and socially acceptable operation of large-scale testbeds.

From a network asset perspective, enhancing connectivity and sustainability is crucial. While government-led networks are relatively easy to initiate, maintaining them—and ensuring active, voluntary participation from startups—remains a significant challenge. Nevertheless, networks are indispensable to the ecosystem: in rapidly changing markets, entrepreneurs rely on them to access timely information and adapt strategies accordingly. For policymakers, networks offer a valuable channel for obtaining feedback on policy measures. Hence, careful consideration is needed regarding the government's role in establishing and supporting startup-centered networks that are both dynamic and self-sustaining.

Ultimately, all three asset types are essential; each on its own is insufficient to produce unicorn companies. Economic assets are embedded within physical assets, and their nature may shift depending on the physical context. Likewise, human resources situated within physical spaces form the basis for network assets, while the demands and perspectives emerging from networks influence the development of the other two asset types. These assets interact organically, and their relative importance may vary according to national circumstances and startup profiles. Rather than seeking a rigid balance, it is more important to classify the resources available to a nation or city into these three categories, assess their current state, and pursue their continuous advancement.

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