TITLE: DATA-DRIVEN URBAN PLANNING IN SINGAPORE

ISSUE AREAS

☒ **ICT and SMART technology** ☐ Sustainable mobility ☒ **Land use and nature-based solutions**
☐ Clean energy ☐ Sustainable solid waste management ☐ Building energy efficiency
☒ **Innovative urban governance** ☐ Behavioural change

OVERVIEW

Urban resilience is pivotal for Singapore and it goes beyond just the ability to bounce back from shocks and crises. As the city-state is small with limited natural resources and heavily reliant on trade and human talent, enhancing urban resilience is about integrated and long-term planning as well as good urban governance, to allow Singapore to adapt and thrive in the threat of climate change and demographic change. ICT enables the planning agencies to anticipate, forecast, and balance the socio-economic demands for a better land use planning process.

Over the last couple of decades, Singapore has seized unprecedented opportunities in harnessing ICT and geospatial data to reduce vulnerability through risk-informed decision making, create economic opportunities, improve urban liveability, and build closer communities in its transformation towards a smart nation. Data-driven urban planning enables Singapore to prioritise investments in building resilient and sustainable cities. Singapore has grown into a geo-powering city that harnesses the use of the geospatial data to create meaningful information for the decision makers to make evidence-based decisions. The geospatial integrated system and the "Whole-of-Government" approach has helped Singapore to move away from sectoral egos and towards an ecosystem approach, where the identification of risks and solutions are performed in a collaborative manner, complemented with science, innovation, technology, capacity, and regulation. Through an interactive and coherent ecosystem, they strengthen evidence-based urban planning, together, they create a more resilient and people-centered Singapore.

THE CHALLENGE - WHY HAS THE CITY TAKEN ACTION

The challenge of balancing a multitude of needs in a small area. Singapore is a small island that houses all the needs of an entire city-state. Beyond housing, transport, greenergy and parks, culture and heritage, the city-state also has to find space for other needs, such as seaport, defence and water catchment, all of which has to fit into a land area of 721 square kilometers (278 square miles)(Huang, 2018), which is about half the size of London. Therefore, in order to balance economic, social and environmental needs and goals, the planners in Singapore require a powerful geospatial integrated system and planning tools for a flexible and resilient urban design.

Singapore is vulnerable to climate change impacts. Addressing climate resilience is essential as Singapore is already experiencing the impacts of climate change as temperature rose by 0.25℃ per decade (1948 to 2016) and the sea level rose by 1.2 millimeter (mm) to 1.7 mm per year. By 2100, it is projected that the temperature of Singapore will rise by 1.4℃ to 4.6℃ with sea levels rising up to 1 meter (m) (URA, 2021). Warm nights, urban heat island effects, strong monsoon seasons and heavy rainfall seasons are more pronounced. Furthermore, Singapore will continue to rapidly develop the new housing estates and growth areas to meet the population demands and economic goals by

2030, thus better planning of the built environment and climate-responsive urban planning is a critical challenge for Singapore.

Changing demographics and ageing population presents a key challenge as Singapore heavily relies on human talents. As an open hub for international talents, the city-state has attracted people from all around the world. Despite that, Singapore's population is ageing, with an estimation of around 900,000 residents aged 65 and above by 2030, which will have an impact on both the economy and society. The demographic shift with a sizable non-resident and elderly population will require good urban and land-use planning for the future. (CLC, 2018a).

Limitations in traditional urban planning tools. Land use planning requires a comprehensive understanding of the ecosystem of the constant-changing environment. Before the adoption of ICT, urban planning was largely based on manual tools, such as paper records, hand drawings, and land surveys. Therefore, the data were often out-of-date, labourious and limited in functionality (e.g. generate conceptual presentations and real-time descriptive analysis). It also failed to produce in-depth planning analysis and keep up with the rapid development and planning requirements (GPSC, 2017). Therefore, the planners were in urgent need of current, accurate, and readily available information so as to make informed decisions on land use planning.

GOALS AND OBJECTIVES

The goal is to leverage advanced geospatial and data analytics to make integrated, evidence-based and effective land use planning decisions to boost a resilient and liveable Singapore.

1. Establish a cross-agency collaborative approach

Data sharing, especially geospatial data, can be an issue. The spatial planning agency in the city might be reluctant to share sensitive data (e.g., disaster risk data) to other public works agencies. The lack of data sharing protocols, data custodianship agreement or mandate prevents agencies from seamless data sharing, efficient and risk-informed decision making. In Singapore's case, the culture of an open, collaborative data-sharing culture is cultivated in line with the wider Whole-of-Government approach in the delivery of public services.

2. Stay ahead of the curve by leveraging geospatial and data analytics

Through advanced ICT and data analytics, planners are able to identify potential gaps and opportunities to plan for the future infrastructure and amenities to ensure that sufficient resources and forward-looking policies are in place to address the needs of the local communities, particularly addressing the demographic shift issue.

HOW DID STI PROVIDE A LOW CARBON AND CLIMATE RESILIENT SOLUTION?

(STI as a means of implementation)
☒ **Improved decision making** ☐ Offering a low-cost solution ☒ **Inclusive decision making** ☒ **Improved governance** ☐ Behavioural change

(STI as a direct technical solution)
☐ Cleaner/more eco-friendly infrastructure ☐ Cleaner/more eco-friendly equipment
☒ **Faster/better/larger data availability/processing**

- How was it innovative? (What enabling policies were employed? What were the local/national government's policy targets, goals and strategies? Were new S&T approaches developed or existing S&T approaches enhanced? Was the cities geography/culture capitalised upon?)

The innovative components can be observed in two-folds: (1) enabling policies and (2) ICT use in the urban planning process.

Enabling policies

From 1980 till this day, multiple national Infocomm Master Plans and e-Government Master Plans have been implemented so far, which not only set the tone and direction for ICT advancements, but also fasten the pace of incorporation of ICT into Singapore's governance (CLC, 2018b):

- *Civil Service Computerisation Programme (CSCP, 1980-1999)* which raises public service efficiency through the effective use of ICT. The Programme started from automating work functions and reducing paperwork, then it involved digital conversion of data. By the early 1990s, the focus shifted to consolidation of computing resources into the form of a shared data centre and a civil service-wide network.
- *Infocomm 21 (2000-2003)* that establishes Infocomm as a key sector of growth, boost competitiveness of businesses and enhance the quality of life through infocomm
- *e-Government Action Plan I & II* that drove public service excellence by deploying 1,600 e-services, and developing integrated services.
- *iGov2010 (2006-2010)* that promoted Whole-of-Government(WOG) integration including the integration of data, processes, and systems for government agencies.
- *eGove2015 (2011-2015)* that focuses on collaboration within and outside the government
- *Digital Government Blueprint (2018-2023)*that aims to build common digital and data platforms for the WOG; strengthen policy, operations and technology integration; and raise digital capabilities to pursue innovation, amongst others.

Innovative urban planning process

The advanced ICT enables the planning agencies to anticipate, forecast, and balance the demand of a growing population and the limited land area without compromising the requirements for economic and development objectives, and the good quality of life, and hence, further address the resilience challenges (GPSC, 2017).

Singapore' urban planning processes have been systemic. The city-state's planners are among one of the first movers in using planning technologies ever since the 1960s (Huang, 2021). In the 1980-90s, the city-state began integrating computing technology for urban planning, adopting computerisation and geospatial integrated systems (GIS). The use of ICT in urban planning helps urban planners to address increasingly complex urban issues, as well as carry out integrated, future-oriented, and comprehensive land use planning.

The Urban Redevelopment Agency (URA), the national urban planning authority of Singapore under the Ministry of National Development has been adopting the GIS system for land use planning since 1995, from Integrated Land Use System (ILUS) and Integrated Planning and Land

Use system (iPLAN) to ePlanners, integrated quantitative urban environment simulation tool (QUEST) and 3D simulations. For instance, the GIS system provides critical tools that enable URA to integrate all available data into a single platform to analyse spatial and temporal patterns at a glance, and understand the interdependencies and flows within the dynamic urban system (URA, 2021).

Building on that, the URA coordinates with partner agencies in different urban subsystems for cohesive planning. In order to gain deeper insights into how the city and each of its subsystems work, the URA has been working closely with partner agencies, including planning for social facilities, such as eldercare, health care, child care, schools, parks, sports and recreation. The URA has been building up geospatial and data analytics capabilities with these agencies to enable the planners to study the usage patterns of various amenities, better identify and prioritize areas for intervention, and evaluable choices and trade-offs.

- **What science and technologies were used? (What does it do? How does it work? How does it address the challenge?)**

Figure 1 illustrates how planners use data analytics and geospatial technologies to gain deeper insights and make more informed decisions in land use, amenities and infrastructure planning so as to address the challenges, thus Singapore's long-term planning needs are met through digitalisation.

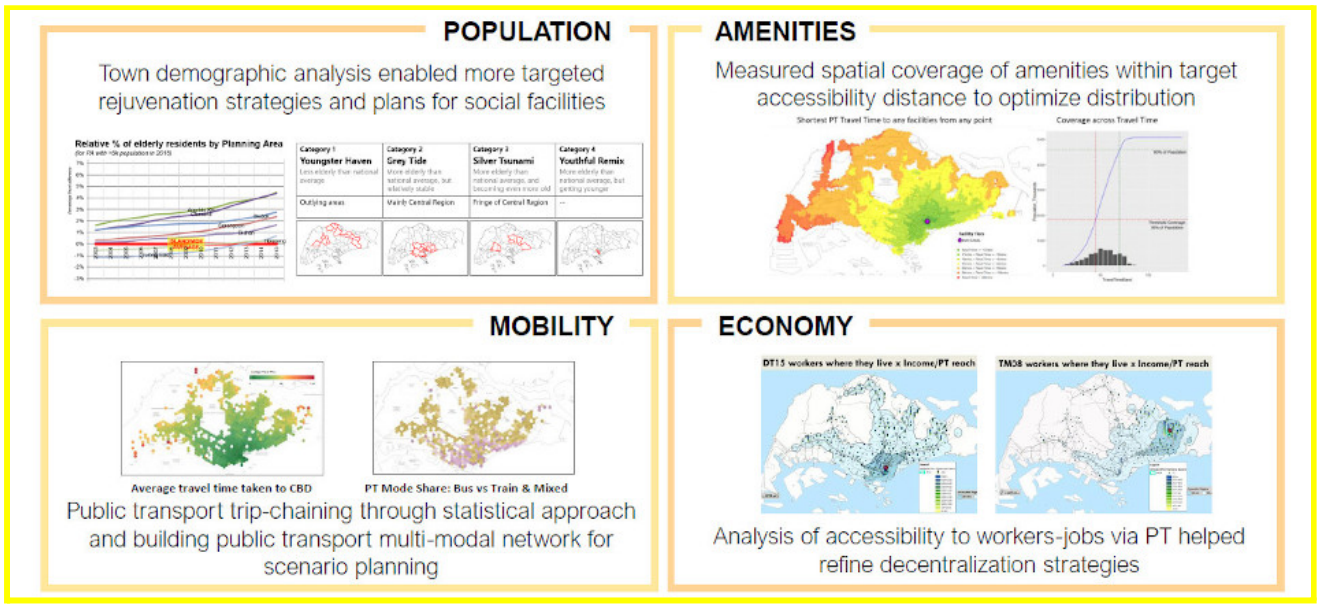

Figure 1. Inform planning decisions with deeper insights from planning analytics studies (Source: URA)

ePlanner

ePlanner is a one-stop multi-platform geospatial urban planning tool. ePlanner allows the planners to perform advanced spatial visualisation and analyse various land use planning information on a single platform. It also provides planners in URA and other over 50 agencies across singapore quantitative and qualitative insights of each area. With easy and quick access to such information, planners are able to anticipate changes, and coordinate with relevant agencies to facilitate integrated planning (URA, 2021).

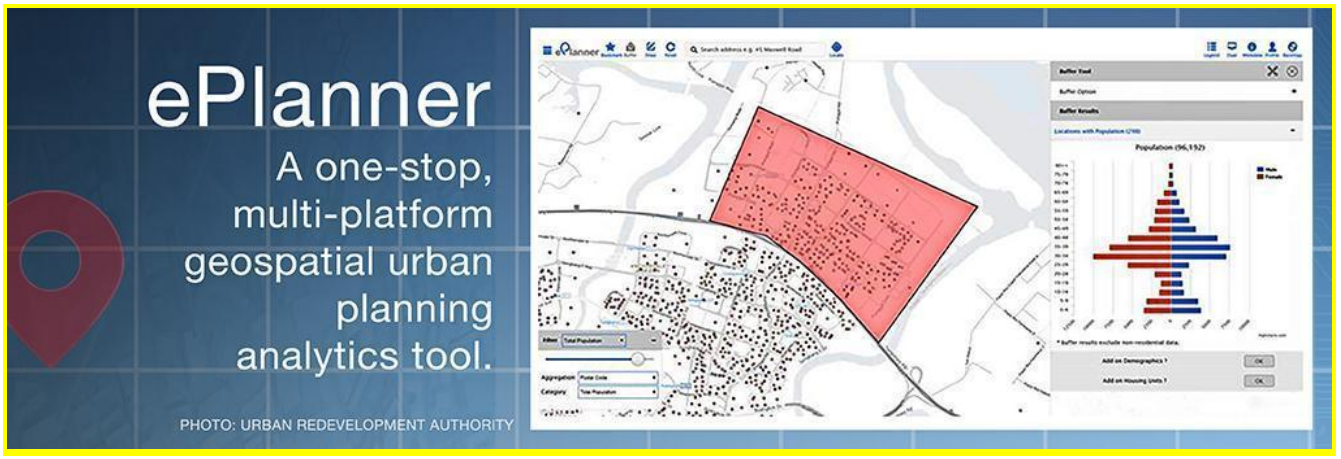

Figure 1: A snapshot of the ePlanner multi-platform geospatial urban planning analytics tool (Source: URA)

Quantitative urban environment simulation tool (QUEST)

QUEST is a tool to stimulate micro-climate and thermal comfort that change with future urban development and climate change. It can be used by planners, architects, and engineers for building analysis and to integrate appropriate urban heat island (UHI) effect mitigation measures upfront in the upcoming land use and urban development plans(Lim, Rajabifard, Khoo, Sabri, & Chen, 2020; URA, 2017; Lim, Ignatius, Miguel, Wong, & Juang, 2017). Hence, QUEST can help with combating the combined impacts of global warming induced rising temperatures and UHI phenomenon. The application of QUEST involves cross agencies and institution collaborations, including URA, National Environment Agency, Singapore Land Authority, Building Control Authority, National Parks Board, and the Agency for Science, Technology and Research, among others, showing the WOG approach (Lim, Ignatius, Miguel, Wong, & Juang, 2017).

The question is how does the tool apply to support two of Singapore's most pressing challenges: the aging population and UHI effect?

Care for the aging population using the geospatial tool ePlanner.

URA has been collaborating with the Ministry of Health (MOH) in the development of a comprehensive social-health database for the aging population. This is built upon the planning and development data on ePlanner. Before this project, data on the seniors was fragmented. Most agencies did not have insights on where the vulnerable elderly reside and if their needs were met by healthcare services and social programmes. The joint database contains MOH's data on the seniors, data from partner agencies such as the Ministry of Social Family Development and Silver Generation Office, as well as URA's planning and development data (Huang, 2018).

By utilizing ePlanner, MOH can not only visualise the ageing population "hotspots", but also make analysis on the accessibility of healthcare facilities. MOH can thus identify and fill the gaps working with healthcare service providers and community-level organisations to plan health and social programmes for the seniors more precisely (Tay, 2021). Hence, the service planning and development of new healthcare and eldercare facilities and services is much more data-driven (Huang, 2018). It is found out that a larger portion of the ageing population lives in the east and northeast regions, and that most of the seniors are residing within 1.5 km of their nearest polyclinic.

With this knowledge, the authorities can allocate more healthcare facilities in areas where the aging population is living and anticipated demand is (URA, 2021).

Combating UHI phenomenon using QUEST

As shown in Figure 2, Singapore has been getting hotter and hotter through the years. Therefore, coping with the UHI effect will compound warming brought by climate change and ensuring thermal comfort for the residents has been one of Singapore's climate-change-adaptive undertakings.

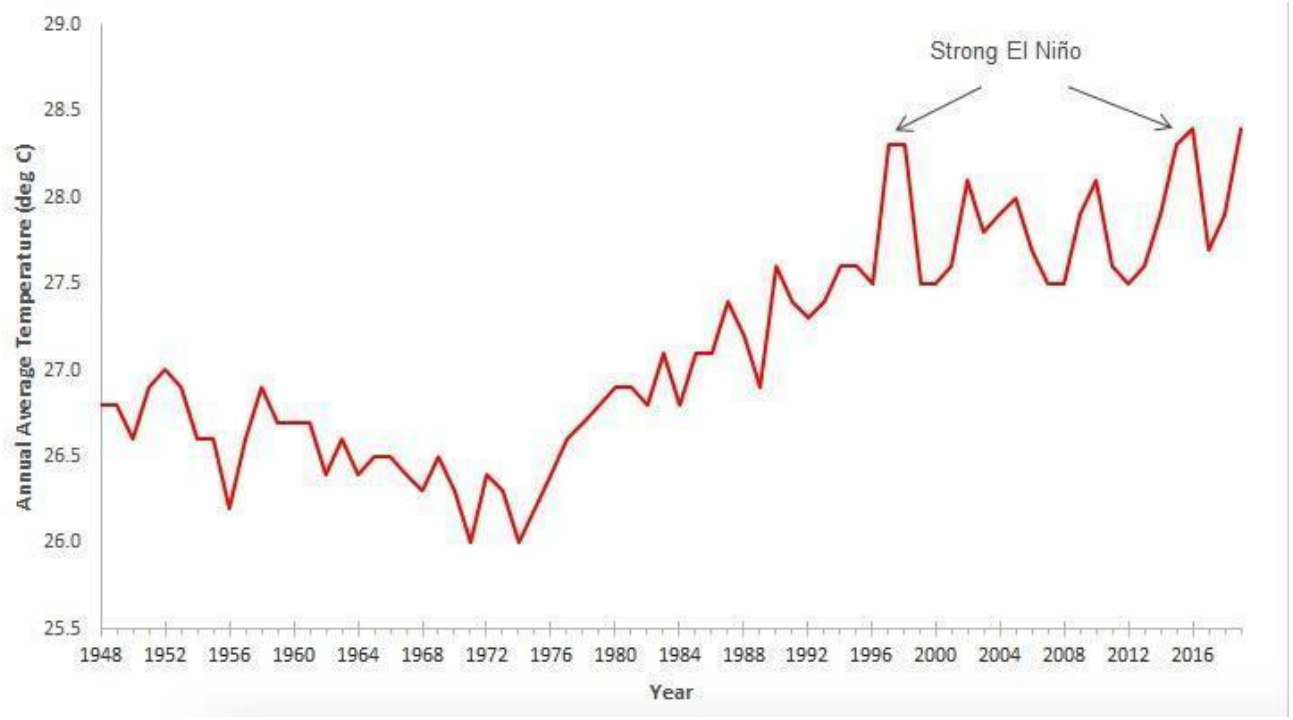

Figure 2. Annual mean temperature in Singapore from 1948 to 2019(Source: Meteorological Service Singapore)

With the support of the Ministry of National Development (MND) and National Research Foundation (NRF) under the Land and Liveability National Innovation Challenge, QUEST combines high-resolution atmospheric modelling with urban-scale computational fluid dynamics modelling to generate various parameters, namely wind, temperature and thermal comfort index at multiple urban scales. QUEST allows planners to visualise how the new addition to the built environment will affect people's thermal comfort levels as well as test the effectiveness of various intervention strategies, such as increasing greenery and adjusting building orientation and massing for shading and good wind flow.

Users can obtain results and outputs from an island-wise scale to a district, neighbourhood, or even a building-level scale to support urban design to mitigate UHI effect and growing temperatures due to global warming.(Lim, Rajabifard, Khoo, Sabri, & Chen, 2020; URA, 2017).
Figure 2 illustrates the different components and work packages that consist of QUEST.

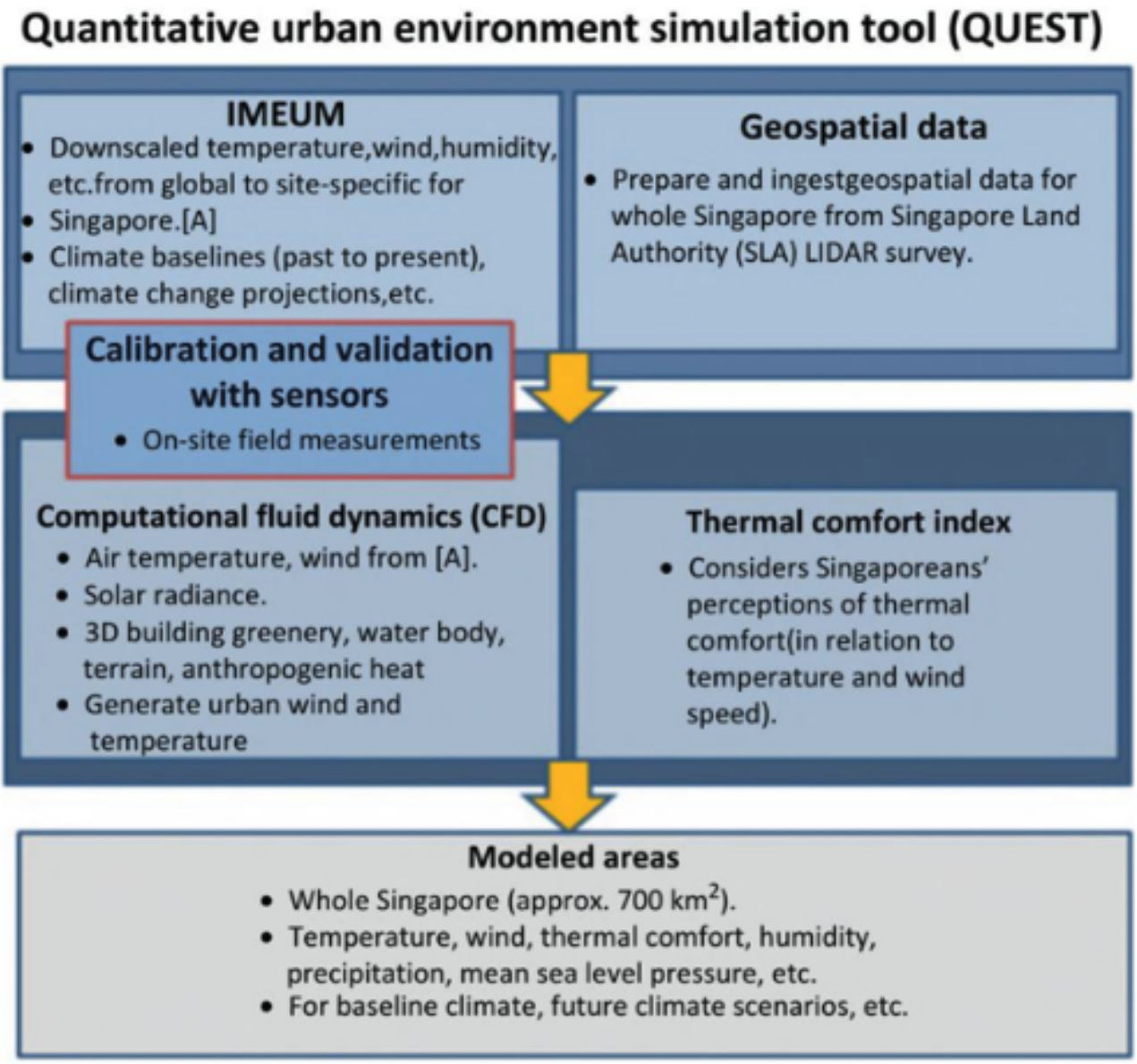

Figure 2. QUEST's work packages and components (Source: Lim, Rajabifard, Khoo, Sabri, & Chen, 2020)

ePlanner and QUEST demonstrate how Singapore has been able to stay ahead of the development curve by leveraging ICT and smart technologies in urban planning processes, and providing planners with a more holistic understanding of the urban ecosystem. Therefore, the city-state is planning with higher granularity to create a more resilient and liveable environment (URA, 2017).

KEY AREAS OF CONSTRAINT/SUPPORT

INFRASTRUCTURE REQUIREMENT

In April 2008, Singapore's National Spatial Data Infrastructure (NSDI) and Singapore GeoSpatial Collaborative Environment (SG-SPACE) was launched. SG-SPACE creates linkages between the Land Data Hub (see section down below) and other national data hubs for people, business and security respectively. The initiative has facilitated informed decision-making and development monitoring by coordinating the use of geospatial information across the public sector (Centre for

Livable Cities, 2018). Such infrastructure and data connectivity allowed comprehensive big data collection through real-live and actual user interaction.

POLICIES AND REGULATIONS

Figure 3. shows eGovernment Masterplans (see above section) that cultivate data-informed decision making governance.

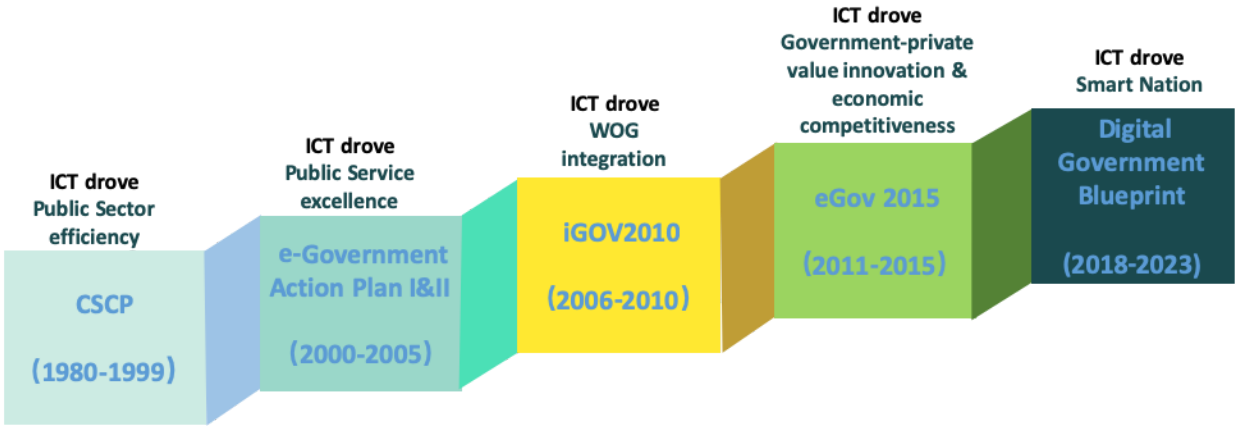

Figure 3. eGovernment Masterplans, 1980-2025 (Source: CLC, 2018)

THE SCALE OF THE PROGRAMME/PROJECT

This is a city-nation-wide urban planning.

TECHNOLOGY CAPACITY

Technological progress in computer modelling and sensing capability and the development of GIS have made the use of data analytics and geospatial technologies in urban planning possible.

COST AND FINANCING /BUSINESS MODEL

Public funding.

HUMAN RESOURCE CAPACITY

The set-up of URA's Digital Planning Lab in 2013 brings together planners and data specialists to use digital tools to improve planning processes and outcomes. The approach is holistic, with different professions working together to combine insights (Morwenj, 2020). The mission of the Digital Planning Lab is to incubate skills and ideas, to accelerate insights and transformation, and to inspire, through innovation and partnerships. There is a strong focus on building skills and capabilities within government, with the Lab running a data analytics immersion programme twice a year, to train cohorts of government staff on how data can be used in their work (Morwenj, 2020).

POLITICAL COMMITMENT

Singapore has had the same political party in charge of its Cabinet since 1959, making the city-state maintain a high level of autonomy. Therefore, Singapore is able to ensure the continuity for progressing a digital agenda, both within the same government or across different government administrations (McGinty, 2015). Most recently, the Singapore government announced that it will invest up to 3.8 billion SDG on ICT procurement in 2021, an almost 10% increase from 2020 of 3.5 billion SGD, signifying the political commitment towards digitalization and ICT (Gotech Singapore, 2021).

INSTITUTIONAL SET-UP

Established in 1989, the Land Data Hub (LDH) brings agencies including the Land Office, URA, Land Transport Authority, JTC corporation, Building & Construction Authority (BCA), and Housing & Development Board among others, together and acts as the intermediary to exchange and translate data to fit the needs of each agency. The development of LDH also realised the standardisation and sharing of land data across government agencies and reduced duplication of efforts in data collection and creation(CLC, 2018b).

URA is one of the agencies of the Ministry of National Development that guides Singapore's land use planning and urban development, amongst other functions. URA partners with other government agencies, private businesses, and local communities to promote data-driven urban planning so as to enliven urban spaces and provide car-lite, people-friendly and livable cities for all to enjoy.

KEY BENEFICIARIES

Singapore residents.

TIMELINE

1980-present

IMPACTS

CARBON REDUCTIONS
RESILIENCE

Digitalisation supports planners to apply data analytics and ICT tools to support data-informed, climate-responsive urban design, thus helping form communities to the whole city-state to adapt to the impacts of climate change as well as reduce the GHG emissions that resulting from climate change.

CO-BENEFITS (e.g. JOB CREATION, AIR POLLUTION REDUCTION ETC.)

FACTORS FOR SUCCESS

- Political consistency ensures continuity of policies that advance ICT development and its integration into governance

- WOG approach that streamlined cross-agency governance and sharing of data
- Continuous evolvement of digitisation technologies and tools that allow urban planners to perform a more climate-sensitive and adaptive urban design

LESSONS LEARNED

OPPORTUNITIES

Most cities want a good environment and quality of life for their people, as well as a competitive economy where businesses thrive and provide good jobs. The use of analytics in urban planning makes sense only if there is a strategy to turn findings into data-driven solutions.

CHALLENGES

The complexity of city's eco-system

A city is a system within a system, with many interacting parts that come together to create different outcomes under different conditions. Cities vary due to differences in social and economic dynamics, in physical and digital infrastructure, as well as in governance frameworks. Each will have a unique set of priorities and will need tailored solutions. How to simulate them into a digital tool is always a challenging process that requires reiteration, data analytics and simulation.

Maintain the continuity of innovation

Urban planning in the last five decades has been a series of innovations in planning strategy, policy and methodology—the only way to respond to the city-state's changing needs. In this digital age, the ability to harness geospatial and data analytics to strengthen urban planning is important. Hence, URA has equipped the planners with the tools and capabilities to build up their digital competencies in order to transform urban planning practises.

The negligence towards valuable data sets

Many Smart Cities Initiatives, despite the potential, largely focused on Apps development and applications, rather than evidence-driven planning and urban management. Although data is collected, they seldom feed into long term planning. Therefore, the policy makers tend to overlook the city's long-term spatial, and socio-economic development plans, and instead focus on complaints received from apps, which undermines data-driven, risk-informed planning as a result.

Data sharing itself can be an issue, especially for the geospatial data.

The urban planning agencies might not be willing to share the data with the public works or the disaster risk agency. In addition, the lack of data sharing protocols, data custodianship agreement or mandate that enables agencies to seamlessly share data, and the absence of integrated data platforms that host the data and update the data periodically often results in data duplications across different agencies and inefficient planning and development plans.

Another situation is that the data is shared among agencies, but none of these agencies talk to each other, hence, the information stays fragmented. Information in silos also results in duplication in data sets, inefficiency and poor planning in terms of addressing risks.

Mindful for data security

Smart city systems tend to generate a large volume of data, including sensitive data including personal information of citizens like the case of Singapore. As such, appropriate measures must be taken to ensure that collected data are secured and protected by law, to thwart misuse of information and unauthorized access.

SUSTAINABILITY

In order to cope with the rapid pace of development and uncertainties brought by climate change, Singapore plans to become more data-informed by initiating the whole-of-nation *Smart Nation* initiative in 2014. It consists of three pillars: Digital Government, Digital Economy, and Digital Society (Khern, 2019).

With digitalisation being a key pillar of the Government's public service transformation efforts. The release of Digital Government Blueprint (DGB) is a statement of Singapore's ambition to better harness data and new technologies in support of Smart Nation.

When it comes to digitalisation in urban planning, a good foundation has been laid by previous efforts of digital data integration, and data science tools and advanced GIS capabilities development. URA is now pushing the frontier of digital toolkits such as Artificial Intelligence (AI) solutions for optimal data-informed urban planning. AI tools are enabling URA to optimise land use, improve citizens' accessibility to services and amenities, and manage utilisation of infrastructure. In the long-run, this allows the planners to plan in a more anticipatory and agile manner to ensure that the plans stay relevant and cater to the changing needs of the residents in the post-pandemic era.

TRANSFERABILITY

City stakeholders can introduce similar collaborative mechanisms and e-platforms that will foster the integration of ICTs into urban operations and create a network of devices for public use and benefits.

EFFICIENCY/EFFECTIVENESS
INSTITUTIONAL CONSTRAINTS/SUPPORTS

The political consistency is one of the main reasons for the maintenance of the continuity for advancing a digital innovation and integration agenda in and across different government agencies.

FURTHER INFORMATION / CONTACT

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