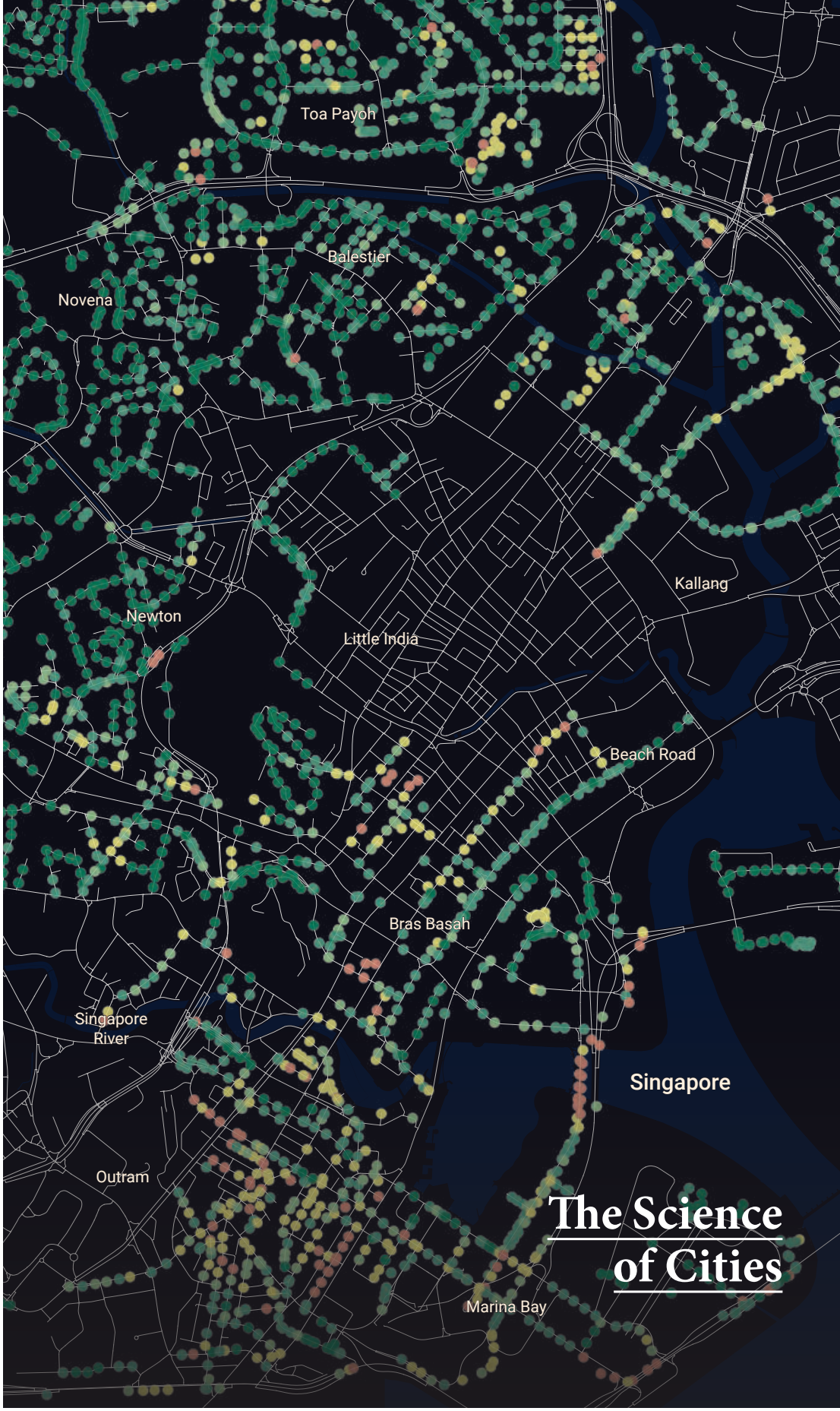
ISSUE 20 • FEB 2022

URBAN SOLUTIONS



The Science of Cities

INTERVIEW
Chng Kai Fong
Carlo Ratti

CITY FOCUS
Shenzhen

OPINION
Josef Hargrave

ESSAY
Michael Batty
Eleri Jones, Tim Stonor & Ed Parham
Peter Ho

CASE STUDY
Melbourne
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CENTRE for LiveableCities SINGAPORE

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URBAN SOLUTIONS is a bi-annual magazine published by the Centre for Liveable Cities. It aims to equip and inspire city leaders and allied professionals to make cities more liveable and sustainable.

Set up in 2008 by the Ministry of National Development and the then-Ministry of the Environment and Water Resources, the Centre for Liveable Cities (CLC)'s mission is to distil, create and share knowledge on liveable and sustainable cities. CLC's work spans four main areas—Research, Capability Development, Knowledge Platforms, and Advisory. Through these activities, CLC hopes to provide urban leaders and practitioners with the knowledge and support needed to make our cities better. For more information, visit www.clc.gov.sg.

Editorial Team
Dinesh Naidu
Erwan Xiao
Gareth Conceicao
Genevieve Shaun

Editorial Consultant
Tuber Productions Pte Ltd

Design Consultant
Green House
Design + Communications

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Contact

Centre for Liveable Cities
T +65 6645 9560
E mnd_clc_publications@mnd.gov.sg
W www.clc.gov.sg

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Singapore 069118

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- 14: Sara Magni
- 15 / 16(1) / 16(2): MIT Senseable City Lab and Alm Lab
- 18 / 19: MIT Senseable City Lab
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Cover Image: The quantity of street-side greenery in central Singapore, as calculated from Google Street View panoramas. *Image: MIT Senseable City Lab / Adapted by Erwan Xiao*

The Science of Cities

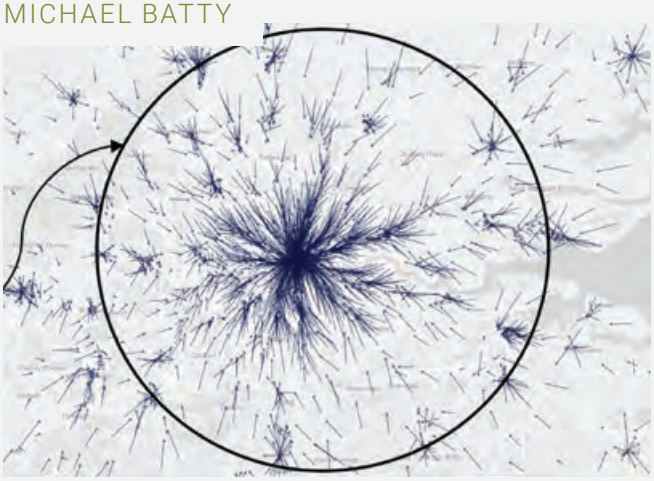


"The understanding of cities through data—which many people refer to as the 'new science of cities'—is vital." 14

CARLO RATTI

"We cannot predict the future but we can use these ideas to inform the debate and initiate scenarios." 38

MICHAEL BATTY





"The idea is to start big, think holistically and slowly zoom into priorities right from the start of a project."

JOSEF HARGRAVE 34



"The actual function of place—as opposed to their intended function—follows the flows set up by the spatial form of those spaces."

46

ELERI JONES, TIM STONOR & ED PARHAM

"The key is for both the public and private sectors to recognise their roles and limitations, and to work together in concert."

06

CHNG KAI FONG





"There needs to be a willingness to try things out, to experiment with new approaches and solutions."

PETER HO

54

Contents

INTERVIEW

The Importance of a "Science of Cities" Approach for Singapore 06
CHNG KAI FONG

Better Urban Planning with Science and Data 14
CARLO RATTI

CITY FOCUS

Urban Design Strategy and Preservation of Historical Features 24
SHENZHEN

OPINION

Science is Not Enough. We Also Need Imagination. 34
JOSEF HARGRAVE

ESSAY

The Emergence of a Science of Cities 38
MICHAEL BATTY

From Smart City to Space Syntax: An Analytical Language to Plan and Design Cities 46
ELERI JONES, TIM STONOR & ED PARHAM

Leveraging the Science of Cities to Solve Complex Urban Challenges 54
PETER HO

CASE STUDY

Orbiting Melbourne: The Case for Improving the City's Mobility 72
MELBOURNE | TRANSPORT

Thailand's Plastic Waste Problem and Its Road to Zero Plastic Waste 78
THAILAND | CIRCULAR ECONOMY

The ePlanner: Integrating Data for Inter-agency Collaboration 84
SINGAPORE | DIGITAL CAPACITY BUILDING

ILLUSTRATION

Visualising the Science of Cities 62
GARETH CONCEICAO & ERWAN XIAO



From the Executive Director

An Evolving Toolbox for the Urban Future

The world is seeing an unprecedented growth in the digitalisation of cities even as they grapple with old and new urban challenges linked to the rapid growth of the urban population. Once regarded as an inorganic entity, the city can now be seen as more of a complex organic system. This has created the impetus for a more deliberate approach towards understanding the city and its challenges, representing a new "science of cities". Not surprisingly, cities have come to value data as a central resource, to understand the movements of the city, both its inhabitants and its processes, and to improve the daily lived experience for city-dwellers.

The new science of cities as the platform for better urban living.

Michael Batty and Peter Ho expound on the need for the science of cities in their essays. With increasingly complex urban systems found within cities, the interactions of these systems with one another and their emergent outcomes have become the focal point for productive solutions to urban challenges of today. Chng Kai Fong explains why a science of cities approach is essential for cities today and the role of governments in enabling this.

Data and digitalisation become pivotal in understanding the city.

As Eleri Jones and Tim Stonor assert in their essay, technology is an important facilitator for urban solutions. By mapping human patterns and lifestyles, we can attempt to understand how the city could shape or be shaped by these experiences. As the city is about its people, digital tools and solutions have to adopt a people-centric approach, taking into account the irrationality of human choices, behaviours and patterns as highlighted in the interview with Carlo Ratti. However, data alone is just one part of the equation: Josef Hargrave shares insight on how urban planners and policymakers can leverage scientific knowledge and imagination to holistically craft a city that is resilient to the urban challenges of the future.

The new science of cities paves the way for the future city.

The new science of cities can be daunting for planners and designers alike, yet they can be encouraged by the blueprints of successful cities. Cities such as Shenzhen have shown the fruits of a robust, data-centric planning approach to rapidly develop into a bustling, sustainable, and smart metropolitan city. Large-scale digitalisation initiatives involving both the public and private sector have facilitated the refinement of once-old master planning approaches and broadened avenues for inter-disciplinary collaboration, enhancing city living in Singapore and Melbourne.

As the approaches towards understanding the city have evolved across the last century, so too have the challenges of the modern urban society. We see in Thailand that some problems have origins and solutions that cross city boundaries, and that understanding the underlying complexity is essential in tackling them. This Urban Solutions issue seeks to illustrate that the science of cities is an approach integral to the future of cities. As the world ventures into an increasingly connected, vulnerable and complex state, cities have to remain as stalwarts of better living for all.



Hugh Lim

Executive Director
Centre for Liveable Cities

IN CONVERSATION WITH
CHNG KAI FONG

The Importance of a "Science of Cities" Approach for Singapore

Second Permanent Secretary of Singapore's Smart Nation and Digital Government Group (SNDGG), Chng Kai Fong, speaks about how the "science of cities" approach has helped to develop Singapore and why it continues to be important for the city-state.



Image: Smart Nation and Digital Government Group, Singapore

> The way to find short-term solutions is to create a tight loop of experimentation where one could try an approach, get results quickly and adjust the trialled method.

As cities grow increasingly complex, an interdisciplinary science of cities methodology has developed to understand them. Why is this approach important for a city like Singapore?

Singapore is both a city and a country: we are a country with no "countryside" outside the city. This imposes on us many more dimensions and variables compared to a typical city. For one, Singapore is the only city in the world that has a military and foreign service. Cities do not need them. Second, all the gateways that cities thrive on—ports, airports, data centres and submarine cables, and all the critical infrastructure that cities sustain themselves on such as power generation and water treatment plants—need to be within the city. There is no moat, or drawbridge that separates the city from outside. Third, Singapore cannot specialise economically—we have to have a sizeable manufacturing base, about 20% of our GDP. We cannot be a purely service economy like London, Hong Kong or New York, with high paying jobs in finance and banking at one end, and low-end jobs providing food services at the other. We need a spectrum and a thick middle layer of jobs at all levels, catering to all Singaporeans of different skills and experiences. To translate this into land terms, we devote almost 50% of our land to the military, gateways, reservoirs and manufacturing. That's not even counting other things we need to cater for living: housing, roads and rail, nature reserves and parks.

But most importantly, as a country, we must have a national identity. It is not just the economic dimension, but the social and political dimensions that we have to optimise for. Our history is such that our people did not come about and cohere naturally. Singapore began out of conviction, that different races could come together in a multiracial and meritocratic environment, and survive despite having no natural resources.

Therefore, we have no choice but to be inter-disciplinary.



Buses in peak hour traffic, Singapore.
Image: Seloloving / Wikimedia

What are some examples of how a science of cities approach has helped in tackling complex city issues and challenges?

One example is how we use public transport data and a combination of experimentation and infrastructure upgrades to solve congestion problems.

We had a novel way of figuring out how crowded our buses and trains are at different times of the day. As such, we could predict when and where the choke points would occur, and then experiment on what we can do with it. Public transport is ultimately a problem about managing peaks. You could solve it either by building additional infrastructure, which takes time and money, and can be very wasteful—or find workarounds to relieve peak loads. For example, using off-peak incentives to shift travel patterns by 10%, or injecting additional buses/trains. While the former continues to be important for long-term planning, the way to find short-term solutions is to create a tight loop of experimentation where one could try an approach, get results quickly and adjust the trialled method.

> The public sector has to plan for the long-term and sustain purposeful action over time.

How has Singapore enabled such an approach, both in the public and private sectors?

We first have to recognise that both the public and private sectors play different roles, and have to constantly navigate and negotiate with each other. The public sector has to plan for the long-term and sustain purposeful action over time. Without doing so, we would not have been able to get a Marina Bay; we would not have been able to convert the whole of Singapore

into a water catchment area; we would not have been able to build up an efficient public transport system. The private sector has a key role to play too—it can innovate, find new and more efficient ways to do things, it can sustain activity, and it moves fast.

> **The key is for both the public and private sectors to recognise their roles and limitations, and to work together in concert—sometimes with tension, but always with a productive outcome in mind.**

Former Deputy Prime Minister and the economic architect of modern Singapore, Dr Goh Keng Swee, once wrote in 1972: "One of the tragic illusions that many countries of the Third World entertain is the notion that politicians and civil servants can successfully perform entrepreneurial functions." His point was that politicians and civil servants should focus on what they do best, while leaving businesses to the entrepreneurs and professionals.

In a similar vein, Alain Bernard, in his book *Order Without Design*, talks about the tension between planners (public officers) and economists (from the private sector). "We are facing a strangely paradoxical situation in the ways cities are managed: the professionals in charge of modifying market outcomes through regulations (planners) know very little about markets and the professionals who understand markets (urban economists) are seldom involved in the design of regulations aimed at restraining these markets. It is not surprising that the lack of interaction between the two professions causes serious dysfunction in the development of cities. It is the story of the blind and the paralytic going their own ways: the planners are blind and act without seeing, while the economists are paralysed as they see but do not act.



The Marina Barrage transformed Singapore's Marina Bay into a freshwater reservoir.
Image: © CEphoto, Uwe Aranas

The key is for both the public and private sectors to recognise their roles and limitations, and to work together in concert—sometimes with tension, but always with a productive outcome in mind. The public sector needs to intervene because a laissez-faire attitude does not always work. But the public sector also needs to recognise that the private sector and the market do work to impose some order, and not all order is the domain of the public sector.

Let's talk about SNDGG, which is made up of the Smart Nation and Digital Government Office (SNDGO) and Government Technology Agency (GovTech). We know that SNDGO plans and prioritises key Smart Nation projects while GovTech is its implementation arm. What role does SNDGG play in bringing the public and private sectors together, and in creating a culture of innovation and experimentation that is necessary for the science of cities? And what are some of the challenges or barriers in taking this approach?

First, data. We need to bring data to the conversation. By having proper governance and transparency around data, we enable urban planners and the private sector to work with each other and find new ways to do better.

Second, building digital infrastructure for the nation. We need to be hands-on and get to the ground, rather than only being in ivory towers, planning. For example, by building tools—identity, payments, communications—that enable the digital economy to thrive, we enable both the public and private sectors to use these tools to build services and products to serve Singapore.



The Singpass Digital IC barcode being scanned at a polyclinic self-service kiosk.
Image: Smart Nation and Digital Government Office (SNDGO), Singapore

> **We need to be hands-on and get to the ground, rather than only being in ivory towers, planning.**

Third, attracting digital talent into the public sector. If we believe that both the public and private sectors need to work together, we cannot have digital talent only working for tech companies. We must continue to have a government that can hold its own and work with the private sector productively. We will also need to be humble in learning from others—from other cities and countries, and other people.

As for the challenges, our fundamental problem is success, because there is too much to lose, and success entrenches practices and values that have worked for us over time. So we have to develop a divine discontent: to be always dissatisfied with the way things are, but yet be grateful for what we have.



Smart Nation Ambassadors speaking to members of the public at the SkillsFuture Month X Smart Nation roadshow at Our Tampines Hub.
Image: SNDGO, Singapore



Minister for Communications and Information Josephine Teo speaking to Mr Keith Lee, senior commercial account manager at software company VMware at the SkillsFuture Month X Smart Nation roadshow at Our Tampines Hub.
Image: SNDGO, Singapore



TraceTogether and SafeEntry—a digital contact tracing system developed by GovTech.
Image: SNDGO, Singapore



A member of the public replacing an out-of-battery TraceTogether token at the TraceTogether vending machine.
Image: SNDGO, Singapore

What changes do you foresee in how new science and technology will change the way cities are planned and run?

US entrepreneur, investor and software engineer Marc Andreessen has said that "software is eating the world", where software is eating much of the value chain of industries that are widely viewed as primarily existing in the physical world. It started with business and industries. As those businesses and industries interact with the real world, software and technology affect governance, urban planning and societies. The changes will be deep and complex, because it is not just about replacing what exists with an app or software. We will have to keep abreast of the changes, and be open to new approaches of governance and planning.

At the same time, while some things fundamentally change, others don't. For example, the need for human connection and community, and the desire for a good life for us and our children. Zoom can help us to traverse distances to communicate with each other but it cannot replace in-person meetings or a hug.

The world is becoming more complex and interdependent. Hence, as city planners, we have to be more adaptable, more resilient, and be able to adjust nimbly, even as we have to develop more conviction about where we are going and be able to rally and tap into our communities to get there together.

As city planners, we have to be more adaptable, more resilient and be able to adjust nimbly, even as we have to develop more conviction about where we are going and be able to rally and tap into our communities to get there together.

IN CONVERSATION WITH
CARLO RATTI

Better Urban Planning with Science and Data

Carlo Ratti, Professor of Urban Technologies and Planning Director at the MIT Senseable City Lab, draws from his past projects to explain how data-driven methods can improve urban planning.



Image: Sara Magni

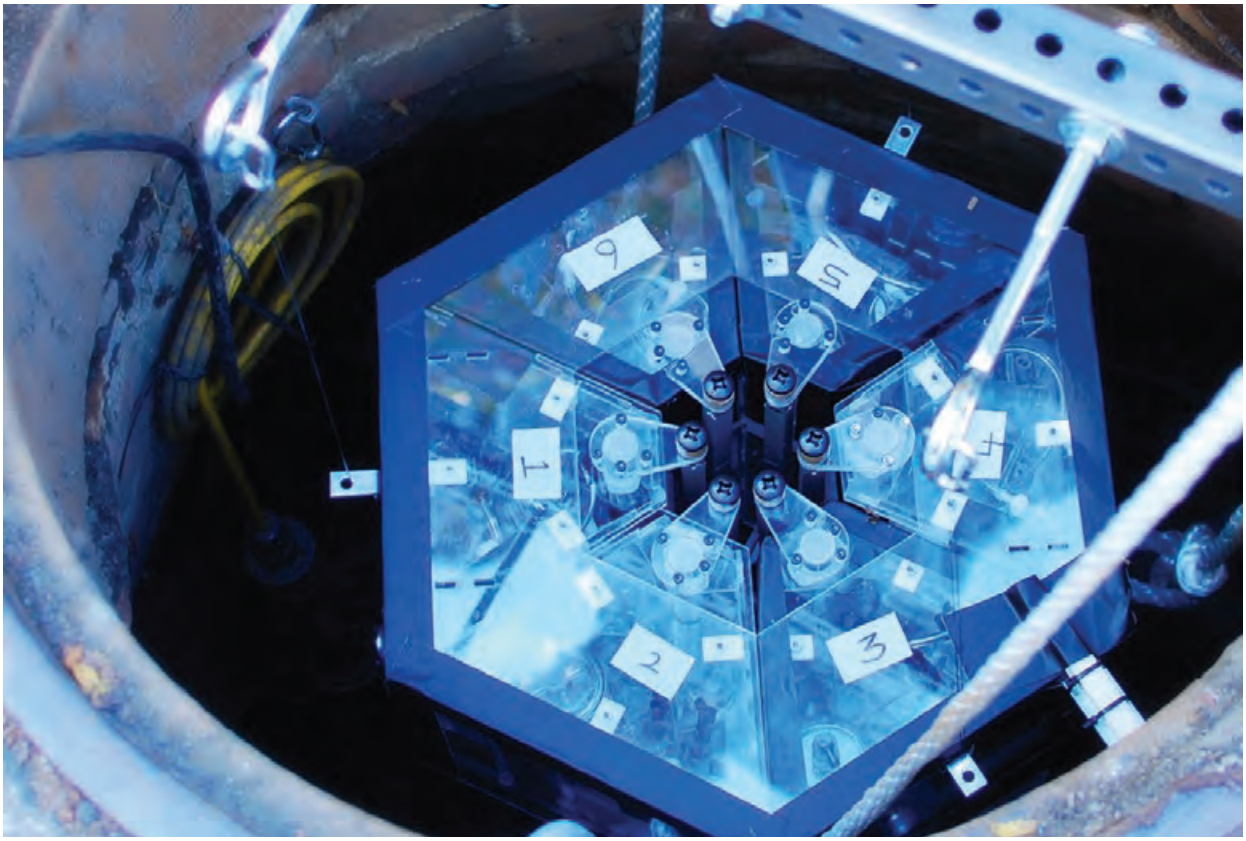
To what extent can understanding and examining the science of cities affect urban public policy? Do you have any examples in your recent/past works?

Evidence-based policy, i.e., the idea that policy decisions should be informed by objective evidence, is gaining traction globally. In this sense, the understanding of cities through data—which many people refer to as the "new science of cities"—is vital. As an example, at Senseable City Lab under the Massachusetts Institute of Technology (MIT), we were involved in the Underworlds project, which employs robots to retrieve wastewater samples from the sewage system.



Taking wastewater samples as part of the Underworlds Project.
Image: MIT Senseable City Lab and Alm Lab

Underworlds started as an MIT-wide research initiative, with experiments conducted in the US city of Cambridge, Massachusetts; Seoul, South Korea; and Kuwait City, Kuwait. The small robots we placed into the sewage system act in two phases: the motion system positions the instrument centimetres above the wastewater using a bipolar stepper motor, nylon line and proximity sensors. After sampling, the motor reverses to wind the line and thereby lift the instrument back to street level.





Robots designed by MIT Senseable City Lab to collect wastewater samples from the sewers.
Image: MIT Senseable City Lab and Alm Lab

> The understanding of cities through data—which many people refer to as the "new science of cities"—is vital.

The filtration system concentrates ingredients of wastewater, including bacteria, on a filter—which is later analysed in the lab with metagenomics, metatranscriptomics and metabolomics.

The initiative successfully detected the flow of bacteria and viruses in real time and resulted in a start-up called Biobot. It was founded by Mariana Matus and Newsha Ghaeli—researchers who were involved in the Underworlds project. The start-up is a combination of this experience and their expertise in biology and urban studies. Over the last few years, Biobot has been collaborating with different US cities to conduct tests and most recently, provide feedback on COVID-19 policies.

In your work Desirable Streets, the research findings highlighted several factors such as shop frontage and parks, rather than the shortest path, that encourage pedestrian activity. How do you think these scientific methods could shape the planning of streets in the future?

Long before I could run an experiment, I had a hunch. Twenty years ago, I was a student at the University of Cambridge, and I realised that the path I followed between my bedroom at Darwin College and my department on Chaucer Road was, in fact, two different paths. On the way to Chaucer, I would take one set of turns. On the way back home, I would take another.

Surely one route was more efficient than the other, but I had drifted into adapting two, one for each direction. I was consistently inconsistent, a small but frustrating realisation for a student devoting his life to rational thinking. Was it just me or were my fellow classmates—and my fellow humans—doing the same?

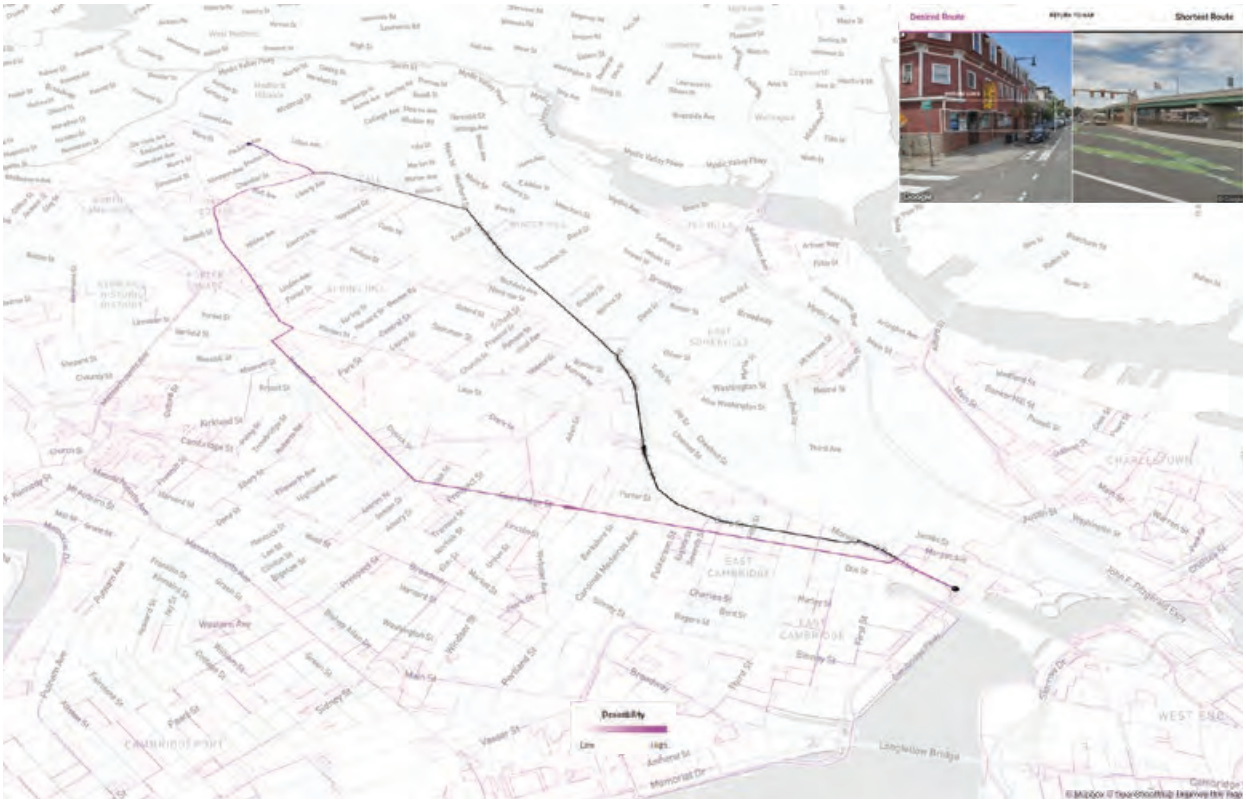
Today with Big Data we have an answer to this question. We discovered that the most predictive model, representing the most common mode of city navigation, was not the quickest path. Instead, it is one that tries to minimise the angle between the direction a person is moving and the line from the person to their destination.

This finding appears to be consistent across different cities. We found evidence of walkers attempting to minimise this angle in both the famously convoluted streets of Boston and the orderly grid of San Francisco. Scientists have recorded similar behaviours in animals, which are described in the research literature as vector-based navigation. Perhaps the entire animal kingdom shares the idiosyncratic tendencies that confused me on my walk to work.

Desirable Streets used thousands of pedestrian trajectories obtained from GPS signals to construct a desirability index for streets in Boston. It was part of a broader investigation into human mobility we have been carrying out at Senseable City Lab.



An analysis of street desirability for streets in Boston.
Image: MIT Senseable City Lab



Calculating the most desirable route between two points.
Image: MIT Senseable City Lab

We need to make sure the technological devices can accommodate our irrationalities. AI should be an ally of organic intelligence.

We recently published another paper in the journal *Nature Computational Science* that finds people seldom take the shortest route to reach their destination. Rather, they follow the "pointiest path" that eschews angular displacements, even if travelling at small angles would actually be more efficient.

Such knowledge of human behaviour could be very useful in urban planning, in order to design better mobility networks in cities. Furthermore, we are no longer walking, or even thinking, alone. We are increasingly wedded to digital technologies, to the point that phones represent extensions of our bodies. Technological prostheses do not think like their creators. Computers are perfectly rational. They do exactly what the code tells them to do. Brains, on the other hand, achieve "good enoughs" and necessary compromises. As these two distinct entities become increasingly entangled and collide—on Google Maps, Facebook or a self-driving car—it is important to remember how they are different from each other. We need to make sure the technological devices can accommodate our irrationalities. AI should be an ally of organic intelligence.

Another one of your projects, Copenhagen Wheel, looked at how bicycle movement data could potentially improve planning for future bicycle routes in cycling-friendly cities. Could you elaborate on how data-driven methods like this impact our understanding of urban mobility in a holistic sense?

Copenhagen Wheel was a collaboration between Senseable City Lab and the city of Copenhagen in 2009. The initial idea was simple—an intelligent wheel that could be retrofitted on any bike and by doing so immediately turn it into an e-bike. Once installed and paired with a smartphone, the wheel would be able to sense the force of your pedalling and provide an appropriate level of assistance. It would track the speed, direction and distance travelled, as well as collect data.

As a smart system laden with sensors, it would monitor air quality but also track the speed, direction and distance travelled by the bike on which it is installed.



The Copenhagen Wheel "smart wheel" retrofitted onto a bicycle (*left and right*).
Images: Max Tomasinelli

The project was met with great success. It gave birth to mobility start-up Superpedestrian, which has since invented more sensor-driven mobility devices like e-scooter LINK, with the capabilities of remote diagnostics and even remote maintenance.

Understanding people's biking habits—and that of other types of micro-mobility—is important for envisioning a city's transportation system as a whole. With a well-thought-out set of lanes, more people would consider commuting by bicycle. Such changes could reduce congestion and pollution, and data collection is the first step to achieving it.



> Architects need to join forces with experts from different disciplines to develop comprehensive design solutions.

You also talked about the concept of designing streets to have multiple functions, such that unused space is minimised in order to achieve a higher-density yet sociable environment. What do you think is the role of government and policymakers when it comes to these land-use policies on mixed-use plots, road sharing, etc?

I think governments have an important role to play in terms of incentives—which in turn can promote some of the changes we are discussing. During the COVID-19 pandemic, such transformations on our streets emerged naturally as soon as local governments allowed businesses to expand outdoors. In the future, we could imagine a kind of platform that would allow people to bid and propose uses for such real estate, and as a result allow a dynamic occupation of space.

What do you think is the biggest challenge and limitation that architects and urban designers face in the practice of urban planning and design these days, in terms of keeping up and applying digital technology and data-driven approaches?

One of the main challenges faced by urban design professionals is the increasing complexity of the issues they have to tackle. From a once-in-centuries pandemic to drastic climate change, their scope exceeds the capabilities of one single profession. Architects need to join forces with experts from different disciplines to develop comprehensive design

> This future architect or urban designer is someone who is informed about different fields and capable of mobilising various communities to tackle the most urgent problems nowadays.

solutions. I refer to this new role as "choral architect" in our book *Open Source Architecture*. This future architect or urban designer is someone who is informed about different fields and capable of mobilising various communities to tackle the most urgent problems nowadays. Keeping up with digital technology is crucial in this kind of collaboration because it allows all the parties involved to work together efficiently.

In terms of the choral quality of design, I would like to mention the project CURA. It is an open-source design based on converting shipping containers into mobile Intensive Care Unit (ICU) pods in response to the shortage of hospital beds during the first wave of the COVID-19 pandemic. From design to fabrication, it took us only weeks to complete the prototype, and this was made possible through collaboration among doctors, engineers, medical equipment producers and many more experts from different areas—under the coordination of our designers and architects. It was not easy to get all the parties coordinated, especially at a time when physical meetings were not feasible, and it was up to the team to develop a design solution that bridges the multiple perspectives and most adequately addresses the issue at hand. We published all the plans of the mobile ICU pod on a website, and as a result, companies in the UK, Greece, the UAE and other countries were able to replicate the design and help their local communities.



Mobile ICU pods created from converted shipping containers as part of the CURA project (*left and right*).
Images: Max Tomasinelli



How can data-driven design approaches include more participatory design in which local communities are activated, and heard?

Sharing data—either as raw numbers or as data visualisation—can be a powerful tool to engage communities. There are many interesting examples related to open-data initiatives, such as new citizen-developed apps to better interface with public transportation. Also, digital networks allow new forms of participation, creating feedback loops among designers, city officials and citizens. What I mean by this latter point is that digital platforms enable input and sharing of knowledge in real time—and hence new forms of participation akin to what happens to open-source communities. In this sense, they facilitate a large group of individuals/organisations in being the co-creators of a project.

What is your vision for the role of science-backed, data-driven approaches for cities in the next 20 years?

I expect sensors, Big Data and artificial intelligence to play an ever-increasing role in future cities. Hopefully, this would also be accompanied by widespread data literacy and transparency—so that we can all monitor and be part of such transformations.

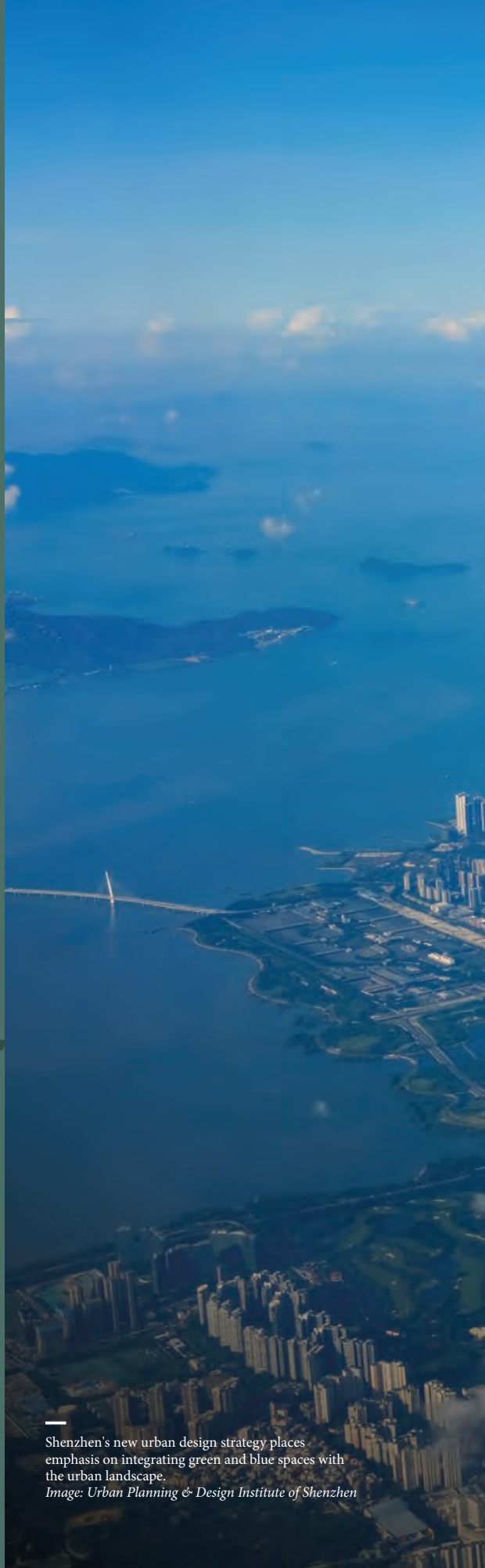
SHENZHEN

Urban Design Strategy and Preservation of Historical Features

TEXT: SHAN LIANG, JING WANLI, LIU HAO AND ZHOU YING

Shenzhen is looking to rebrand itself, and there are calls to do so by revitalising the city with its natural surroundings, among other things.





Shenzhen's new urban design strategy places emphasis on integrating green and blue spaces with the urban landscape.
Image: Urban Planning & Design Institute of Shenzhen



> The “glocal” marries concepts of the “global”, in terms of building a living and working environment with international standards, and the “local”, which seeks to preserve local characteristics and vitality.

The Chinese city of Shenzhen is on a mission to become a model city that demonstrates the qualities of a powerful and modern socialist country with Chinese characteristics.

The city has a vision of creating what has been called “Glocal Shenzhen: A Shenzhen homeland oriented towards the world”. The “glocal” marries concepts of the “global”, in terms of building a living and working environment with international standards, and the “local”, which seeks to preserve local characteristics and vitality.

This overall urban design plan was in line with research for Land Spatial Planning of Shenzhen (2020–2030), which looks into space management and the construction of physical features and infrastructure. It aims to build a so-called Super Bay Area Metropolis that is:

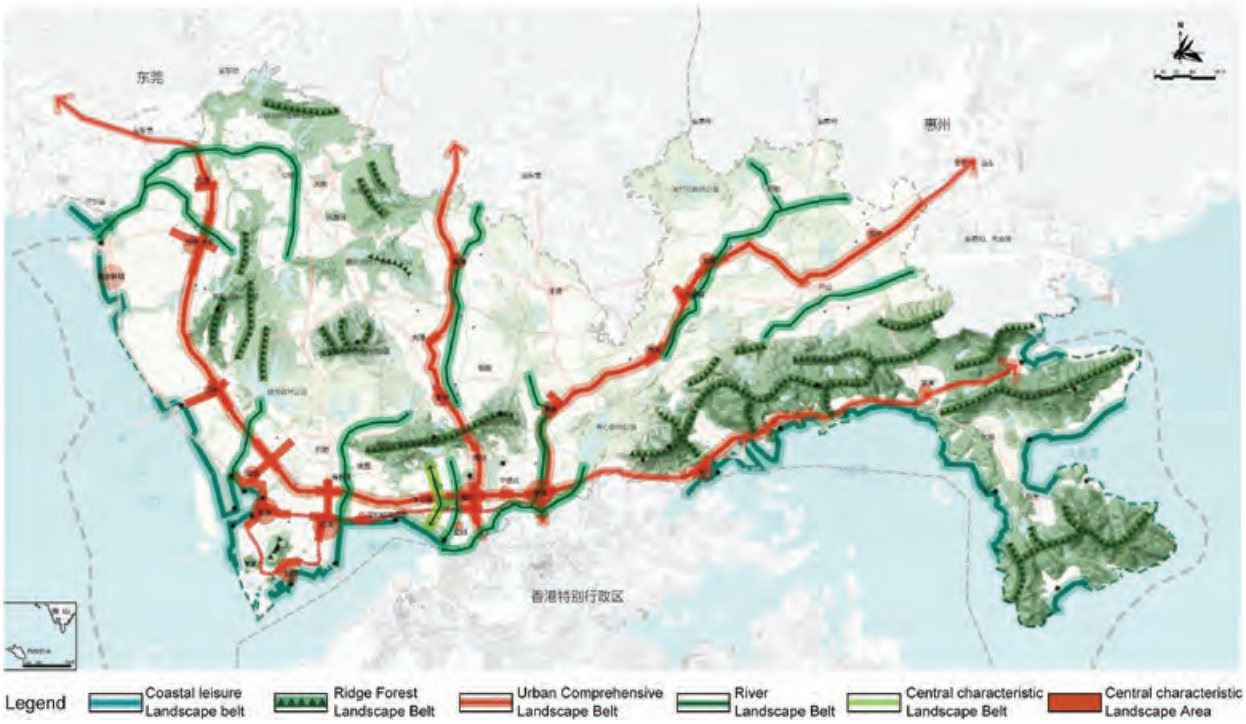
- Dynamic and compact
- A pioneering cultural city
- A world-class city that is more open and diverse
- A city that possesses vitality and attraction

The urban design research applied big data analysis to accurately understand the needs of citizens, and effectively collect their voices by processing and analysing such information. And it precisely and carefully sorted out the most pressing areas to be improved, such as landscape perception experience, public space, urban patterns and activities.

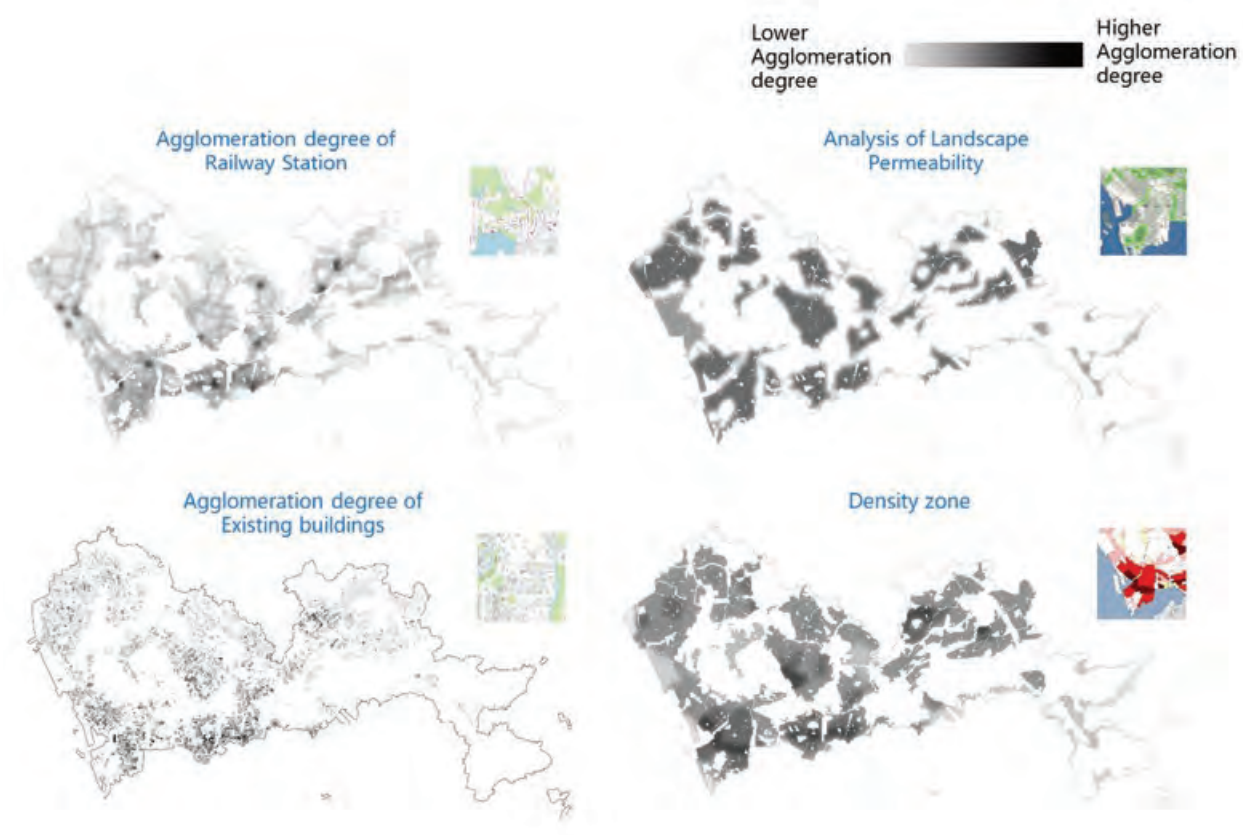
The research had proposed four core strategies:

1. **Integrate the urban landscape with the natural**

   Create interconnectedness between Shenzhen’s natural surroundings such as nearby mountains and the sea with the city. The research suggested building an overall urban landscape pattern of "two wings, four ridges, four belts and 10 corridors":



Overall urban landscape pattern of "two wings, four ridges, four belts and 10 corridors".
Image: Urban Planning & Design Institute of Shenzhen



Big data analysis of multiple urban factors.
Image: Urban Planning & Design Institute of Shenzhen

- Two coastal leisure belts in the east and west of the city, and four groups of Ridge Forest Landscape belts. The idea was to create a semblance of proximity between the city and the hills and seas, further opening up possibilities for leisure, recreation and sports for citizens;
- Four urban comprehensive landscape belts and 10 river landscape corridors that bring nature into the city while retaining its character.

2. **Improve the quality of public spaces**

   Activate, connect and extend public spaces, while ensuring they are of high quality, dynamic, friendly, inclusive and highly accessible.

   For instance, the research proposed 46 urban green belts, equipped with sports, leisure and cultural facilities, renovating the roads with reconstructing potential and adding pockets of green spaces in the streets.

3. **Create urban grids with logical density and high-quality spatial development**

   Through big data analysis of multiple factors such as existing railway infrastructure, natural landscape and the built environment, the research advocated for compact and quality development. For instance, it called for the creation of an overall spatial order that uplifts and integrates key nodes in the bay area.

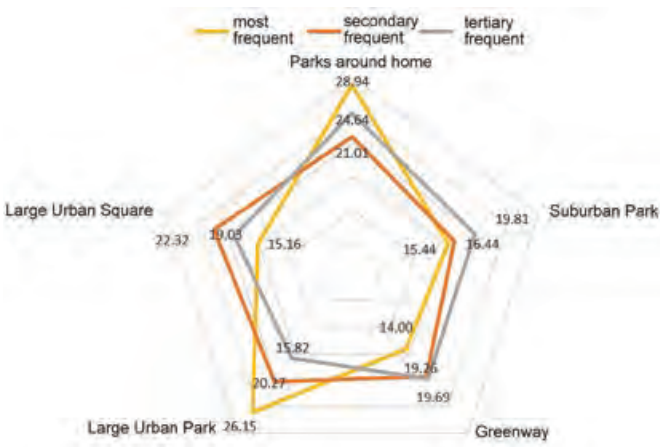
4. **Define five types of natural feature conservation areas**

   A feature conservation area is a space that reflects and records the history of a certain period in time, in terms of its architectural elements and distinctive cultural characteristics. These include urban villages that are steeped in the local character of Shenzhen, and old industrial districts. The plan was to earmark such areas while retaining the communal memory of the special zone development.

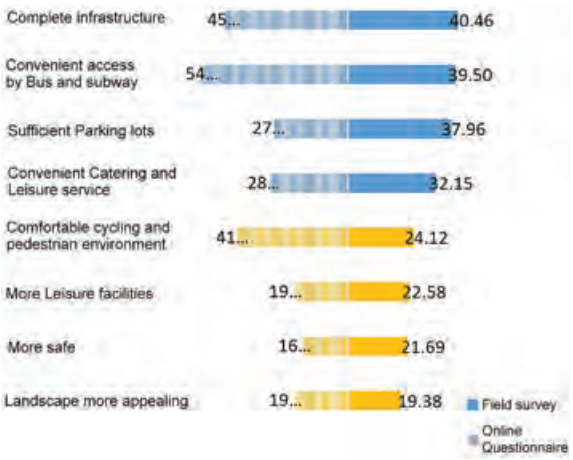
A Multi-faceted Shenzhen

There were four additional aspects to the project. First, it called for the urban design to take on a more organic character. This meant taking into account ecological protection areas, forest parks and other natural features such as mountains and rivers to build what has been described as a "multi-faceted Shenzhen" with a distinctive landscape.

Second, it sought to be oriented by the logic of governance. The project took the approach of viewing public space as the site of consensus-building for public values and how urban districts can be improved. It called for reassessing the value of such urban districts by looking into areas that are thought of as "negative space", while improving the quality of public spaces for people to socialise and interact.



Survey on leisure activities of citizens.
Image: Urban Planning & Design Institute of Shenzhen



Survey of demand on public space.
Image: Urban Planning & Design Institute of Shenzhen



Lianhuashan Park in Shenzhen.
Image: Urban Planning & Design Institute of Shenzhen

> **The project called for amplifying the history and culture of Shenzhen's pioneers to retain an urban memory of the city's specific characteristics.**

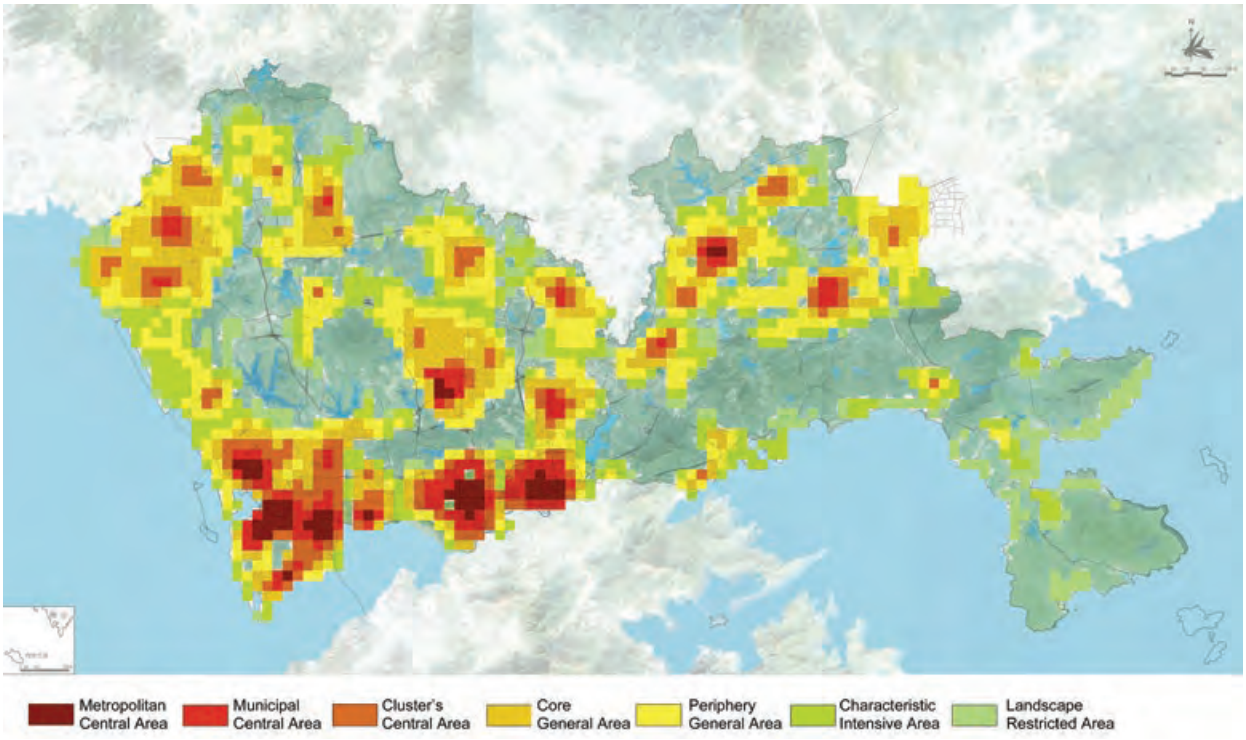
Third, there was a need to protect the urban characteristics of the city. Since 1978, China has embarked on a policy of economic reform that was centred on a socialist market economy and "socialism with Chinese characteristics". With this in mind, the project called for amplifying the history and culture of Shenzhen's pioneers to retain an urban memory of the city's specific characteristics.

Finally, the project proposed pioneering a detailed guide for the control of spaces with a major focus on "zoning by compact levels". This was carried out with consideration for the following: degree of function mixing, pedestrian network density, building height and coverage, and degree of diversity and differentiation of building volume, patterns and features. Among other things, the aim was to create a space where a high variety of functions and services exist, and where their accessibility by foot is prioritised.

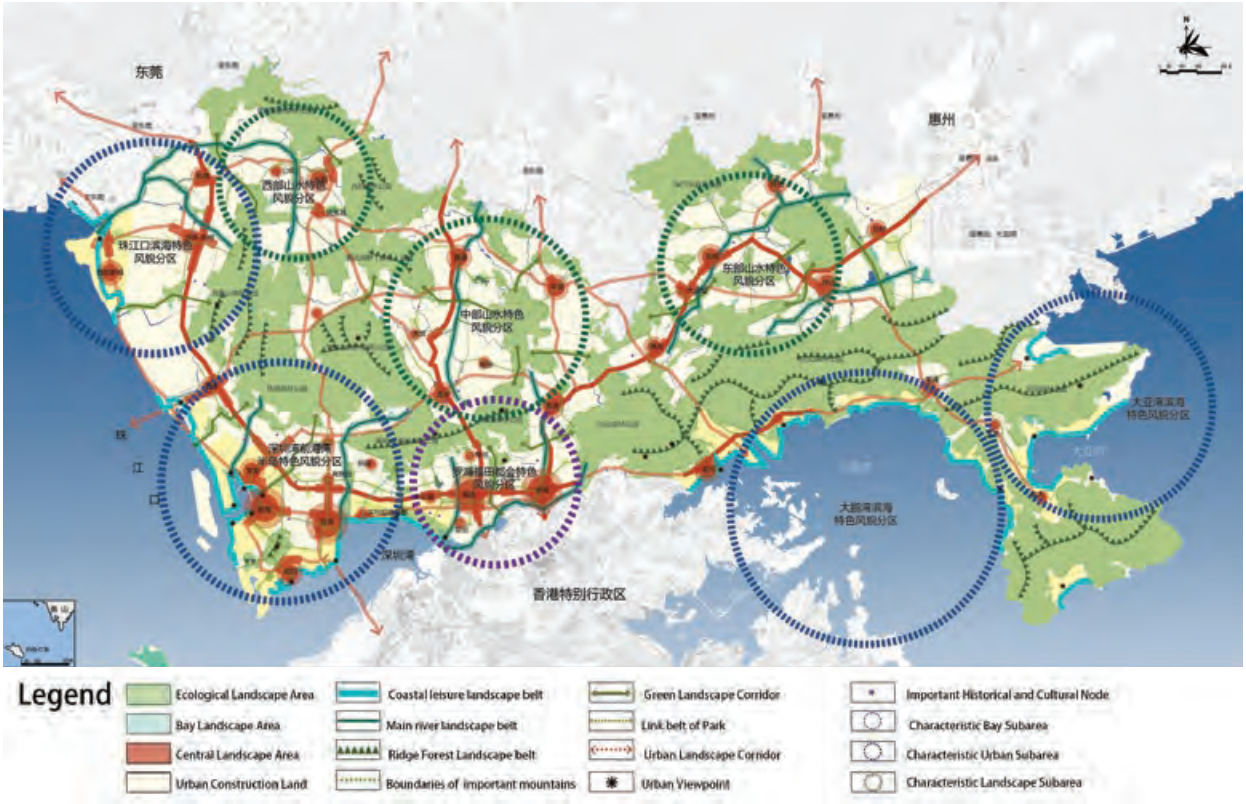


Retaining cultural personality is a key consideration in the rejuvenation of areas such as Nantou Ancient City.
Image: Urban Planning & Design Institute of Shenzhen





Zoning by compact levels.
Image: Urban Planning & Design Institute of Shenzhen



Urban structure of "Four bays, three cities, and one Metropolis" .
Image: Urban Planning & Design Institute of Shenzhen

It puts emphasis on creating a unique city experience based on local environmental contexts, with humanised public spaces, high-quality urban expansion, innovative vitality, and cultural personality.

Implementation

The research vision and core strategy have been effectively incorporated into the next round of Land Spatial Planning, and going forward, it will be the guiding principle for urban design.

The core proposals have been transformed into action plans by the planning management department of Shenzhen to enhance top-level planning and to promote follow up implementations. This involves, among other things, two types of institutional innovation in regulations and design techniques. Another element of this action plan involves "connecting the hills and seas", which was prepared and written into the Government Work Report of Shenzhen in 2020. It effectively pushed ahead the rejuvenation of areas such as Nantou Ancient City and Dapeng Suo City. It has become an important reference point to showcase the urban culture and old memories of Shenzhen.

"This round of overall urban design is different from the previous constructive blueprint. In an urban context where spatial patterns are relatively stable, this novel approach has a stronger focus on transitioning to the modern era and improving quality of life. It puts emphasis on creating a unique city experience based on local environmental contexts, with humanised public spaces, high-quality urban expansion, innovative vitality, and cultural personality" said Shan Liang, the Associate Dean and Chief Urban Designer at the Urban Planning and Design Institute of Shenzhen (UPDIS).

VIEWPOINT

JOSEF HARGRAVE

Science is Not Enough. We Also Need Imagination.



Josef Hargrave, Director and Global Foresight Leader at Arup, a global advisory on design, planning and engineering, explains why urban planners need to integrate imagination into urban planning. His work focuses on the application of future trends, scenario planning, and visioning to the built-environment practice.

> Our discipline often rushes into projects, without first taking a step back and trying to understand the wider context.

Isaac Asimov, the late American science fiction writer, left us, among many things, with this thought-provoking quote: "The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom." There are a number of truths to this.

The first is that science has empowered us with an ever deeper and broader understanding of the world around us. We are living in an Internet- and science-fuelled "age of enlightenment" where almost everything can be known with the touch of a button.

The second is that it is still incredibly difficult for individuals and organisations to make effective use of this knowledge. Incomplete access to knowledge, competing priorities and a lack of integrated thinking often make it impossible to translate all the scientific evidence we have into actionable insights for decision making. Machine learning and artificial intelligence are changing this in some domains, but they still only reach areas where data is plentiful, accessible and useable.

What does this new "age of enlightenment" mean in the context of cities? From my experience, Asimov's view also applies to current thinking in urban design, planning and policy.

When it comes to designing urban spaces, there is so much we could and should know, but fail to make structured sense of. Our discipline often rushes into projects, without first taking a step back and trying to understand the wider context.

Imagine being asked to design a new district in a large city. You start to gather all the evidence to make choices on the provision of transport, the size and typologies of spaces, civil engineering requirements, public services, etc. Before you know it, you find yourself overwhelmed—a modern district must now be age-friendly, carbon neutral, climate resilient, designed using circular principles, and so forth. It is often simply impossible for asset owners/operators, individuals, or project teams to adequately take account of all these priorities and integrate them in a structured and meaningful way.

To address this complexity, urban design professionals tend to allocate responsibility to siloed experts with distinct specialisms and miss out on the opportunity for a truly integrated and holistic approach.

As Asimov argues, a lack of information and evidence is no longer the problem. Rather, it is that we often fail to integrate evidence into a

coherent picture and a common vision when working on urban design. More information does not equate to better decisions.

The other key ingredient urban design professionals often overlook is the forward view: a look into the future, where we ask ourselves how the world could be different, and what this would mean for our design and decision making today.

So how can we address this challenge? We need to recognise the complexity and systemic nature of everything we do. It does not matter if you are designing a single building or an entire city: all projects exist within a complex ecosystem, and this ecosystem is subject to constant change.

What does this mean in practice? I like to use the simple "STEEP framework" that captures the Social, Technological, Economic, Environmental and Political factors driving change within a "system". Teams can do this at the start of every project to help identify priorities and set a common vision.

For example, if you were designing a new district in Singapore, you could use the STEEP framework while considering issues such as the following:

- Social: an ageing population, shifting household patterns
- Technological: energy system transformation, expansion of robotic and autonomous systems
- Economic: future growth industries, scaling up to a circular economy
- Environmental: impact of climate change, biodiversity loss
- Political: changing environmental policy, housing strategy

It is important to identify and discuss these factors with the whole project team, bringing together all stakeholders as part of a single future-focused process and dialogue. This approach immediately brings about a much more diverse and holistic view of everything that matters to a project.

It also enables an early conversation on outcomes. What do we really want to achieve in terms of positive social, economic and environmental effects in the future? How do different disciplines work together to maximise benefits? We build bridges across disciplines,

> The idea is to start big, think holistically and slowly zoom into priorities right from the start of a project.

generate clarity on priorities and start to generate a common vision of what we are trying to achieve.

Analysis of the system, factors and trends driving change can then be supplemented with scientific evidence and the best available knowledge. Collectively, this is utilised to inform the priorities for a future programme, architectural brief, or wider masterplan. The idea is to start big, think holistically and slowly zoom into priorities right from the start of a project. This approach helps to set better foundations from which everything else can grow and ensures that we look into the future whenever we can.

Starting with imagination and setting a strong and ambitious vision allows us to contextualise change, understand future trends, align all relevant project stakeholders and ultimately make better decisions today. It is our attempt to bring together the best of our scientific knowledge and apply it with wisdom.

e ESSAY



COMPLEXITY SCIENCE
MICHAEL BATTY

Michael Batty is Bartlett Professor of Planning, University College London, where he chairs the Centre for Advanced Spatial Analysis. His books *Cities and Complexity* and *The New Science of Cities* elaborate on the ideas discussed in this essay.

The Emergence of a Science of Cities



Le Corbusier's concept of the Radiant City for Paris in 1924 was an early example of modernist master planning that incorporated zoning for different urban functions and systems.
Image: Le Corbusier Foundation © FLC / ADAGP, Paris — SACK, Seoul, 2022

In this essay, Professor Michael Batty from University College London gives a brief history of the emergence of a science of cities, and why some principles of urban science will gain further traction, especially in the post-pandemic city.

> All this was accompanied by a newfound concern for how one might understand existing cities and replan them to achieve a much better quality of urban life. These ideas were contained in the first glimmerings of something that would eventually call itself a "science of cities".

Cities first became significant as objects for intellectual inquiry in the 19th century as the Industrial Revolution gathered pace and new technologies, particularly those associated with transportation, began to make an impact on their form and function. Since classical times, however, it was idealised geometry that dominated what people knew of cities. There was a sustained interest since the 4th century BC in ideas related to optimal or ideal size. It was not until cities began to grow rapidly from the late 18th century that anything resembling a "science of cities" came onto the agenda.

Urban planning developed as a reaction to this rapid growth, dominated by a wave of proposals for sizes and shapes of cities that would alleviate the worst excesses of the Industrial Revolution.



Rapid urban growth has led to strategies of high density living, which has brought about challenges to the quality of urban life.
Image: Manson Yim / Unsplash

The problems of the industrial city—pollution, poor health, very high densities and lack of open space—led to many ideal forms. These included garden cities and modernistic conceptions based on high-rise living in low-density landscapes of greenery. All this was accompanied by a newfound concern for how one might understand existing cities and replan them to achieve a much better quality of urban life. These ideas were contained in the first glimmerings of something that would eventually call itself a "science of cities".

Part of this newly emerging set of theories, although barely thought of as a "science" until comparatively recently, were studies of how human activities such as firms and households locate themselves. This led to notions about how cities were structured and segregated in terms of their demography and economy, and how transportation became the focus of ways in which energy was distributed throughout the city, glueing its component parts together into a workable whole. Beginning with works such as Weber's (1899) *The Growth of Cities in the Nineteenth Century*, a significant flurry of spatial- and land-use concepts emerged by the 1960s. These were thought to be robust enough to ascertain how cities might be planned to function more efficiently, while at the same time providing more healthy and equitable environments.

The general approach which had emerged by this time was quite consistent with formalised thinking in many other fields. It drew on analogies from the physical sciences and articulated many social artefacts such as cities in terms of "systems". The "systems approach" that emerged conceived of such artefacts as being organised hierarchically from the top down. These were composed of subsystems that were held together by interactions which are essentially transfers of energy between their component parts to maintain the system in equilibrium, preserved by positive feedback.

Cities were excellent candidates for such theory. Computers too had been invented alongside these new philosophies of science and had reached a point where rudimentary models could virtually simulate human interaction in space. Once such models had been tuned to particular cities, their predictions and prescriptions could then be systematically explored, leading to designs for better, more sustainable cities.

In fact, although the systems approach propelled the field of urban studies and planning towards a deeper understanding of the form of cities and their liveability, the approach was found wanting in many ways. During the rest of the century, what became clear was that cities were complex systems that defy understanding, and are very different from our knowledge in the physical sciences.

> Cities could no longer be regarded in analogy with machines—they were more like organisms, evolving from the bottom up in ways that were surprising and often counter-intuitive.

The City as an Organism: A Bottom-up Approach

As the technological revolution continued, cities were becoming ever more complex. The understanding that had been gleaned from their earlier study became rapidly dated and less relevant. Planners found it hard to keep up with this increasing complexity and in terms of techniques and tools, had a hard time running to keep standing still. The focus changed radically to one where cities could no longer be regarded in analogy with machines —they were more like organisms, evolving from the bottom up in ways that were surprising and often counter-intuitive.

Thus emerged the science of cities, a science that deals with open systems where the global and the local are entangled in countless ways. In this, interdependencies exist on all spatial and temporal scales, changing the nature of planning from its simpler, top-down conception to an activity that requires us to always recognise these limits.

There are, in fact, many sciences of the city, and this is entirely consistent with the nature of a complex system. Here we will focus on a science that treats the components of the city at its basic level, interacting to produce the kinds of spatial structures and temporal evolution that we associate with a world that is continually evolving in relatively unpredictable ways. The patterns that emerge, however, do have regular properties that can both help our understanding as well as condition us to think about alternative futures.

To this end, we can identify the following:

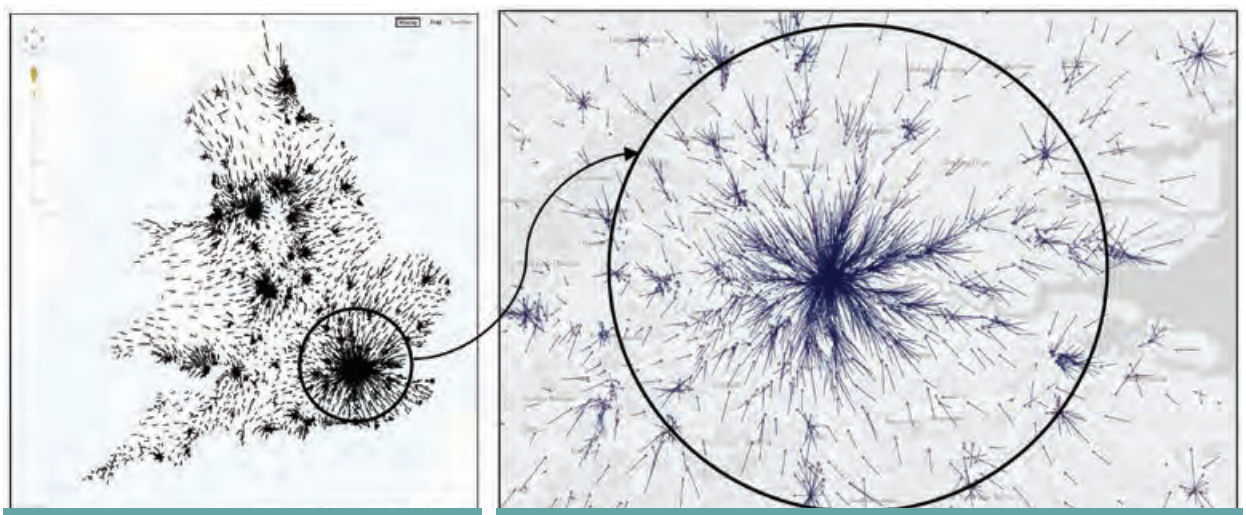
- How cities change in size over time, which we call “scaling”
- How cities are arranged with respect to their “distribution” in terms of their size
- How cities and their subsystems interact over space through “diffusion” and “gravitation”
- How they spread or concentrate
- How locations segregate and cluster
- How inequalities emerge as these processes work themselves out

The Importance of Scale

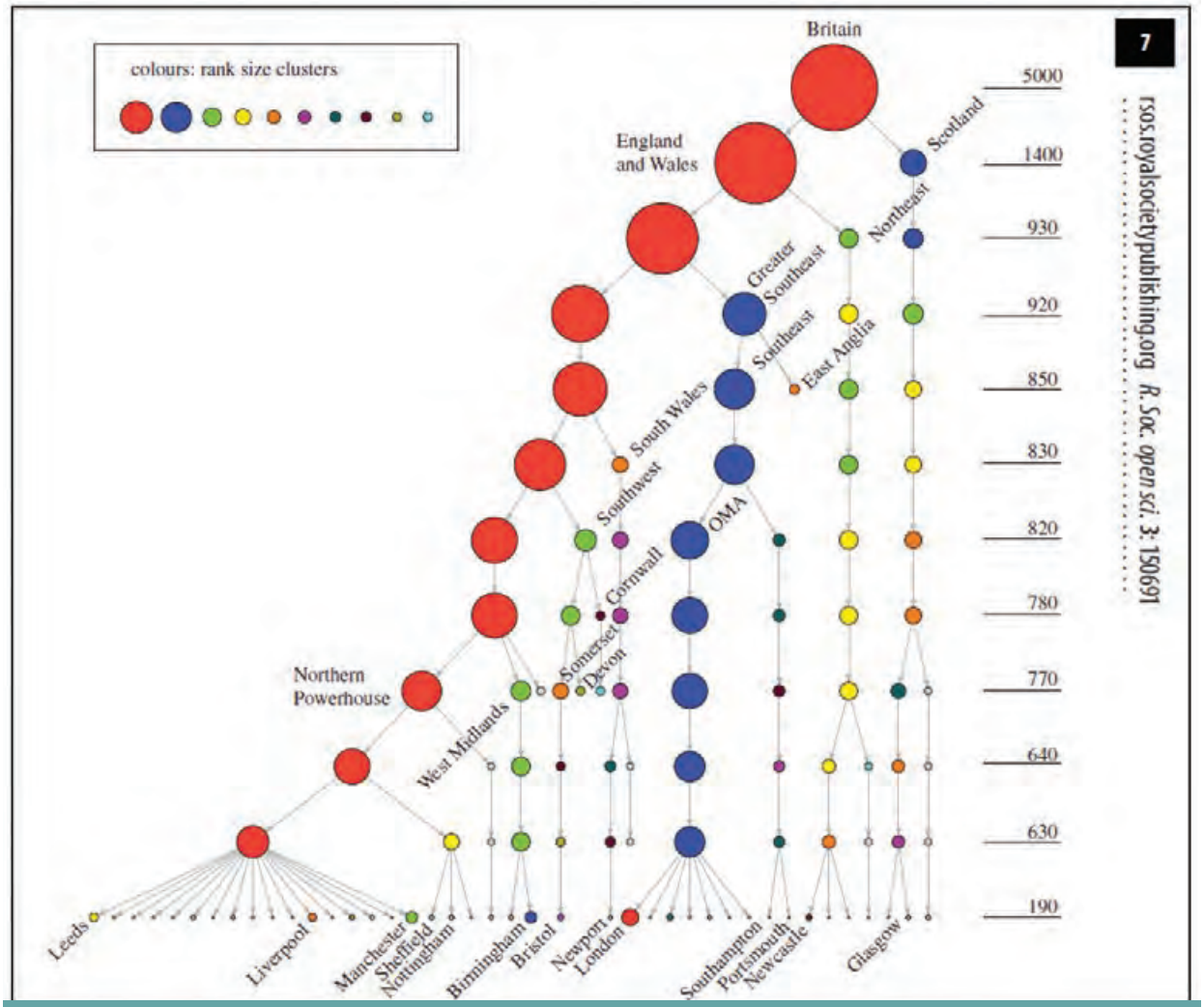
As cities grow in size, they change qualitatively. This can also be observed at increasingly fine subdivisions of the city into different clusters and locations. Generally speaking, urban metabolism operates faster in big cities where people tend to walk more quickly, travel longer distances, and probably work longer hours. Innovation increases more than proportionately with city size and this is called positive allometry from its origins in biology. Over one hundred years ago, Alfred Marshall referred to this as "agglomeration economies" or "economies of scale". It has since been developed quite extensively in the last two decades by the Santa Fe group of complexity theorists led by Geoffrey West and Luis Bettencourt.

The distribution of cities by size also follows a scaling law. This suggests that if we rank cities from the largest to the smallest, the number of cities increases exponentially as their size decreases, and the ratio of one size to the next size down the hierarchy follows a regular progression. The intricacies of these relationships need not bother us, but this rank size rule is a power law that dominates all sizes of objects at whatever spatial and temporal scale we are examining. Of course, this is an idealisation and there is often considerable noise that distorts the underlying relationships, but these properties are still significant and observable. In terms of planning, they suggest that some arrangements of activities in cities that are planned are almost impossible to implement as they break basic laws of human behaviour and defy spatial competition. Their value however is thus to reveal such issues.

At the ground level, the aerial diffusion of activities also follows scaling laws. People interact at a decreasing rate as distance, travel time or cost increases between them. This social gravitation suggests that when places are near, there is more interaction than when they are far from each other. Within this nexus, people of like attributes will tend to cluster. This in turn leads to segregation and to an extent, exacerbates inequalities. Different clusters arrange themselves hierarchically; again, nearly one hundred years ago, the idea that



Directional vectors summarising the gravitational forces defining the hierarchy of cities in the UK and in the London Region.
Image: Michael Batty, CASA

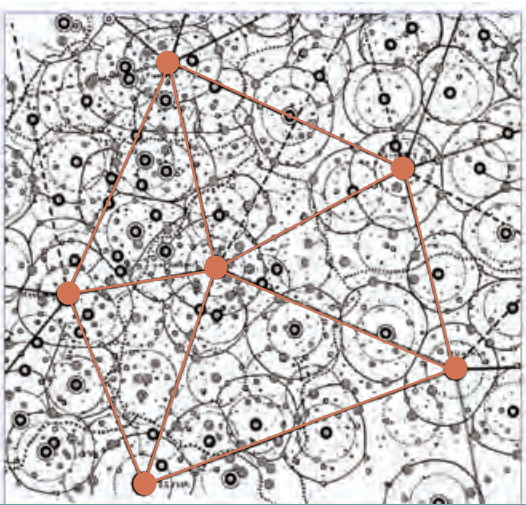


Hierarchy of Urban City and Regional Clusters in Britain

cities and places of increasing size nest themselves in a hierarchy of ever bigger hinterlands dictated how populations accessed increasingly specialist services.

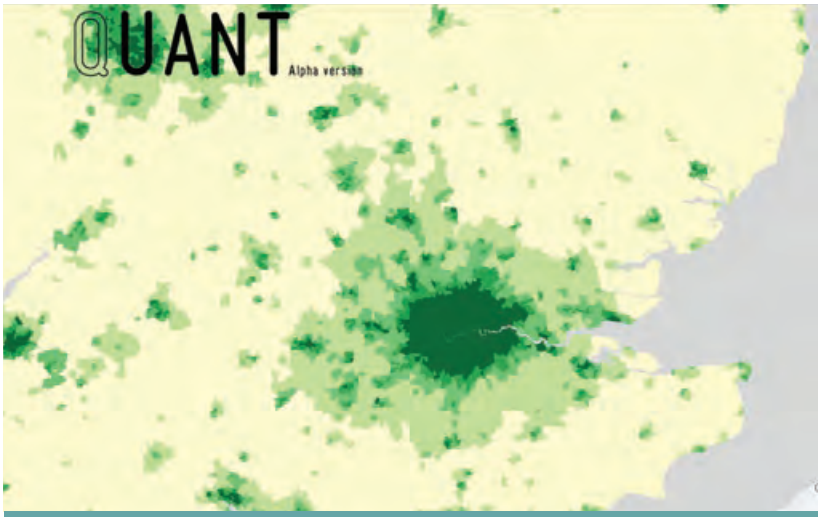
This is "Central Place Theory" first developed by Walter Christaller in 1933 and it lies at the basis of how we link size, shape, form, and interaction using the principles we have just defined. From these relationships, we can explain why the price of land varies, with the highest rents in places that are most accessible, both in the commercial as well as housing markets.

The hierarchy of Central Places with increasingly large and overlapping hinterlands in Southern Germany (*right*), and the equivalent hierarchy of cities and regions in the UK (*top*).
Images: Michael Batty, CASA

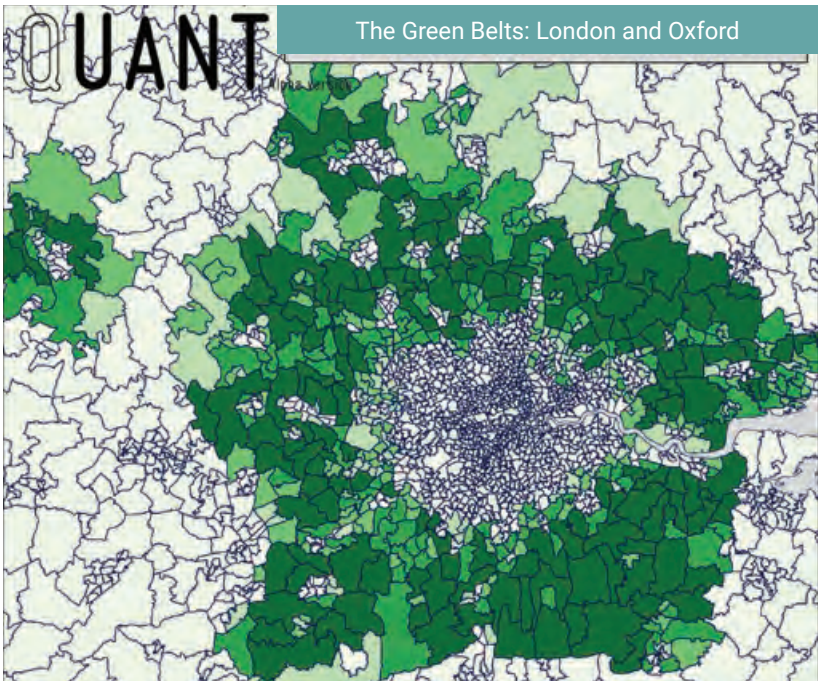


Christaller's Central Places in Southern Germany

The QUANT Model calibrated for Britain which incorporates gravitational fields interrogated using various user interfaces.
Image: Michael Batty, CASA



Job Accesibility in London and the SE



The Green Belts: London and Oxford

Urban Science for Future Cities

We have many models that enable us to translate these ideas into tools for a better understanding and more informed predictive capabilities. We cannot predict the future but we can use these ideas to inform the debate and to initiate scenarios using a whole range of land-use transportation models built around location, central place and gravitational theories. We are able to do this for aggregates of population and economic activity as well as for individual choices using a variety of econometric methods. We are also now able to build these models at a fine scale. Agent-based models illustrate the principles of complexity theory where cities are built from the bottom up, new patterns emerging from the wide array of interactions that are increasingly possible in the contemporary city.

> We cannot predict the future but we can use these ideas to inform the debate and to initiate scenarios.

These tools form an arsenal in a science of cities that is widely applicable globally. By the end of this century, most of the world's population will be living in cities of every size. These cities will be joined together by dense webs of interactions that make them harder and harder to separate into distinct systems that can be understood and planned in isolation. Within the wider region in which Singapore exists, it is clear a very rapid urbanisation is taking place. And although Singapore is clearly one of the world's best organised city states, it is impossible to consider its future planning without continually taking into account this wider environment.

The pandemic has disrupted many of the patterns that have dominated our cities until now; the balance between where we work and where we live, and how we communicate electronically or physically in the future, is as yet unknown. These principles of urban science—scaling, hierarchy, evolution from the bottom up, and rapid globalisation where it becomes impossible to separate one city from another—are increasingly important in thinking about how the forces of centralisation and decentralisation, clustering and segregation in the post-pandemic city, will continue to play themselves out.

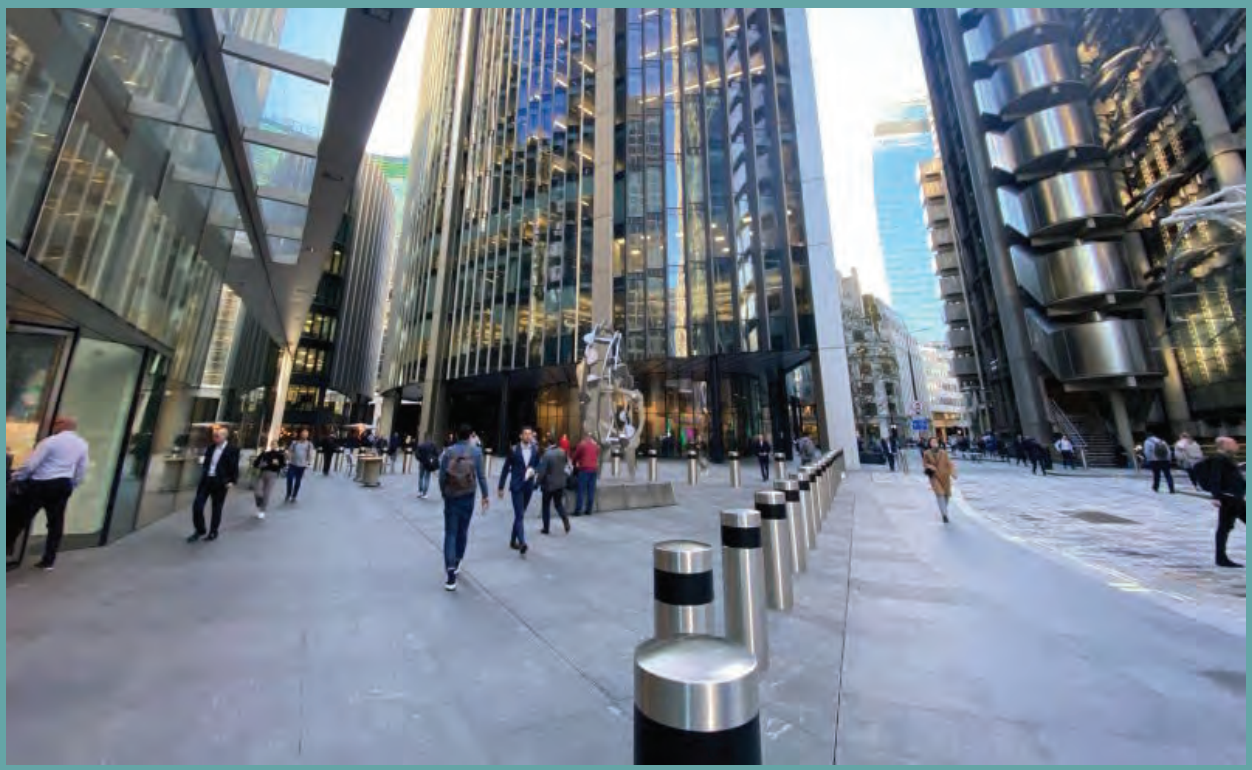




SMART CITIES
ELERI JONES, TIM STONOR AND ED PARHAM

Eleri Jones leads the Urban Policy & Foresight team at Space Syntax. Tim Stonor is the Managing Director at Space Syntax. Ed Parham leads the Studio and Digital service streams at Space Syntax.

From Smart City to Space Syntax: An Analytical Language to Plan and Design Cities



Function follows flow and form—people movement in London.
Image: Space Syntax

The concept of the "Smart City" has been useful to highlight how cities and towns can be developed using digital technology, but the time may have come for a new approach.

The COVID-19 pandemic has led to a re-evaluation of many accepted norms, especially around mobility and work, making now a good time to consider what we want our towns and cities to be like and the potential of technology to deliver policy objectives.

Smart City as Drivers for Future Urban Change and Policymaking

"Smart City" has become a contentious term—early projects were often expensive, did not fully deliver and embedded top-down models in city operations. Nevertheless, the term remains widely used as shorthand for the use of digital technology in planning and operating cities. But a new approach to Smart Cities is being facilitated by developments in technology as well as changes to wider social, political, environmental and economic contexts. In particular, the COVID-19 pandemic has led to a re-evaluation of many accepted norms, especially around mobility and work, making now a good time to consider what we want our towns and cities to be like and the potential of technology to deliver policy objectives.

A Smart City uses technology to make urban life better for people. This means using data and modelling techniques to understand how the planning and operations of the urban environment influence the everyday behaviours of people, and how this then leads to social, economic and environmental outcomes. For example, regular driving to work is associated with a higher risk of negative health outcomes, worse air quality, traffic congestion and carbon emissions.

The physical and spatial makeup of towns and cities plays a fundamental role in shaping human activity patterns—for example, the way streets, land use, densities and public transport combine to make it easier to walk to work or school. Understanding the influence of the urban environment makes it easier to set realistic and long-term policy objectives.

Urban policymaking is being transformed by two key factors, namely climate and health. In the UK alone:

- Around 75% of England's local authorities have declared a climate emergency and are developing road maps to reach zero carbon
- The Welsh Assembly has adopted the Well-being of Future Generations Act, requiring all decisions to consider long-term impacts
- Cities including London are voluntarily reporting on UN Sustainable Development Goals
- The National Health Service has published a long-term plan based around prevention, place and technology

> This means thinking about cities as systems of systems: of street connections, land use attractions, transport links and service infrastructures.

These same drivers are guiding the development of new Smart Cities technologies. At the same time, many new digital solutions are being developed by networks of SMEs, rather than corporate giants, in ways that allow integration and cross-pollination. Instead of creating a one-size-fits-all solution that is expensive and potentially difficult to adapt, future Smart City solutions are being constructed from an interoperable ecosystem of tools and datasets.

Other new developments concern project lifecycles: any project, from idea to outcome, must go through several stages, including policymaking, planning and design to construction, operations and maintenance. At each stage, evidence-based analysis and outcomes-focused predictive modelling can help decision-makers. Many previous Smart City solutions (and many Digital Twin solutions) have focused on the later stages only of the project timeline, for example managing city traffic lights using live traffic flow data. Such solutions can improve performance but will not fundamentally address the reasons why so many people are driving in the first place.

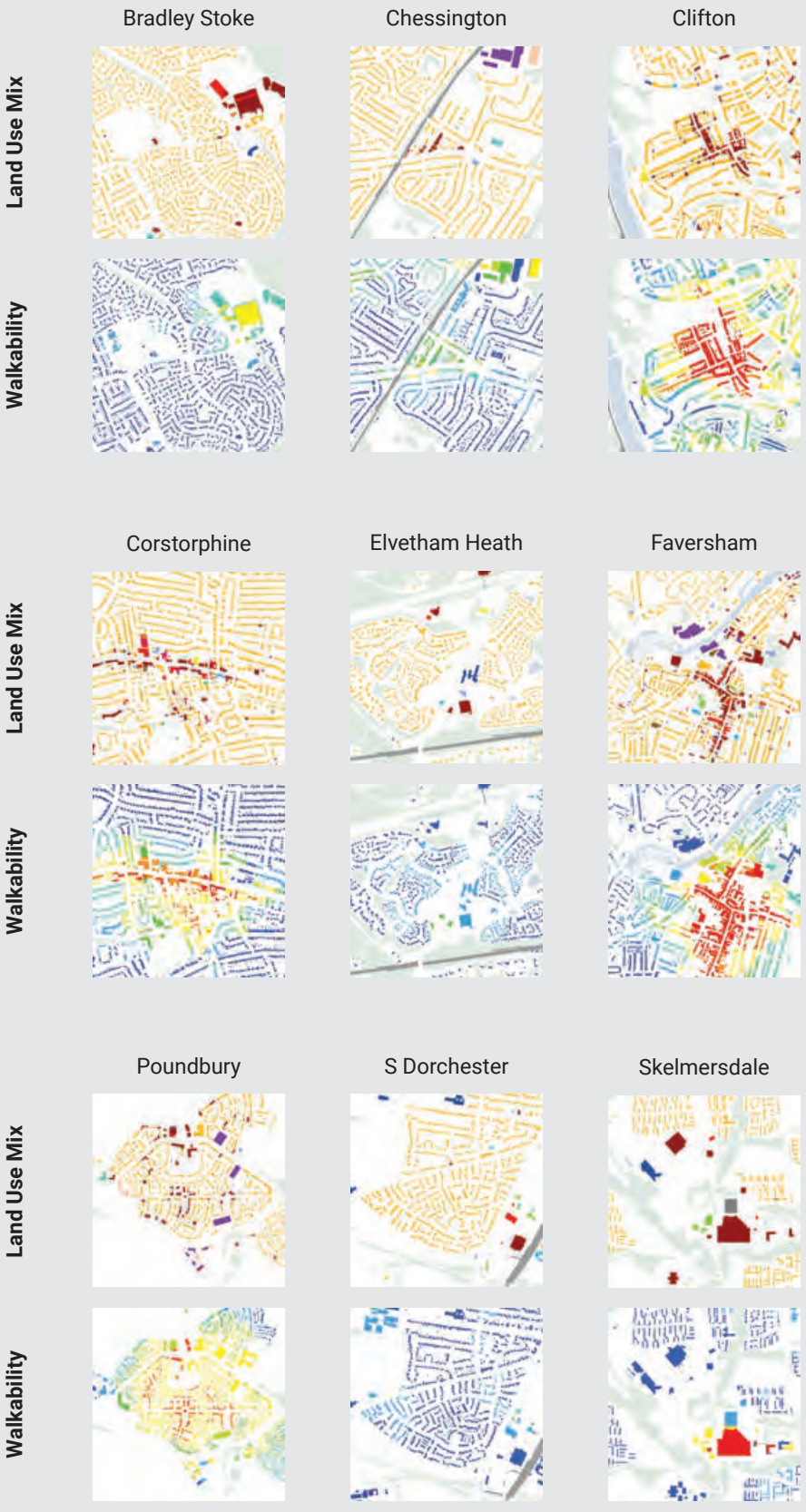
Understanding why and where something happens requires not only technology solutions but domain expertise to explain the way cities work. This means thinking about cities as systems of systems: of street connections, land-use attractions, transport links and service infrastructures. This allows the analysis of how each system works in isolation, and in combination with the others. The UK National Digital Twin programme proposes an ecosystem of connected digital twins to foster better outcomes from our built environment. To make early policy and planning decisions, while still enabling operational decisions to be made later on, it advocates the use of interoperable technologies that match suitable levels of data and processing power to each stage of the project. Its urban modelling systems, such as the Integrated Urban Model, make it possible to use aggregated, anonymised data to help planners in three key policy activities:

- Recognising existing problem areas and targeting physical interventions in response
- Designing better new places which support different behaviours
- Identifying how to mitigate existing physical conditions through non-physical methods

For example, Space Syntax's Walkability Index of the UK uses an Integrated Urban Model to highlight the physical factors required to encourage low-carbon mobility.



Walkability Index National Modelling System (*above*); close-up of land use mix and walkability analyses (*right*).
Image: Space Syntax


Bradley Stoke
Chessington
Clifton
Land Use Mix
Walkability
Corstorphine
Elvetham Heath
Faversham
Land Use Mix
Walkability
Poundbury
S Dorchester
Skelmersdale
Land Use Mix
Walkability



Nur-Sultan Masterplan.
Image: Space Syntax

> Impact assessments can be undertaken on accessibility that take into consideration the social, economic and environmental effects of development on mobility, land value, resilience and health.

From Smart City to the Science of Cities: Space Syntax

Beyond technology and tools to improve infrastructure, there is a need for "smart" physical planning. We can call this Smart Planning, but in many ways, there are many layers to consider that are not as direct as a Smart City approach.

Integrated Urban Modelling, together with other data-driven tools and methods, acknowledges that the city is complex with many interdependent components. It drives well-informed decision-making through systematic evaluation and predictive analytics assessments. It approaches the city through a street network lens—based on graph theory to understand movement flow and behaviour theory to examine accessibility. Through this model, impact assessments can be undertaken on accessibility that take into consideration the social, economic and environmental effects of development on mobility, land value, resilience and health.

For example, Space Syntax has applied its approach to the city of Nur-Sultan, Kazakhstan. Deploying a unique, "data-driven design" approach, Space Syntax has led an international team of consultants to improve, intensify and grow the capital city of Kazakhstan.

The city's 2030 masterplan covers three scales: city-wide strategies, opportunity area masterplans and local, tactical interventions. City-



Nur-Sultan Masterplan movement patterns.
Image: Space Syntax

wide strategies include the use of forecasts of population and employment growth to improve and intensify the city in key areas before extending it. Space Syntax created a bespoke Geographic Information System (GIS) plugin, allowing city users to access advanced analytic tools, to ultimately deploy improvements at scale across the city.

Through scenario modelling, the masterplan demonstrates how the three key objectives can be delivered through a target set of development proposals:

- Improved liveability: enabling 20% more residents to be able to walk to key services, activating parks as vibrant social spaces, and using urban form and massing to create a sheltered and comfortable environment at street level
- Improved sustainability: developing policy roadmaps that would enable the city to reach its emission and recycling rates, and tapping into renewable sources of energy generation
- Creating conditions for healthy lifestyles: supporting daily activity, reducing average car dependence by 10%, and offering equal access to employment by active and public transport as by car

Advanced analysis was used to identify spatial conditions associated with these outcomes in cities around the world, before translating these findings into a set of design principles. Digital and parametric design processes were used to translate these principles into spatial propositions which were continually analysed and refined.

In order to apply these tools and analysis effectively, it is essential that key urban concepts, such as Walkable Urban Centres and people movement flow, are properly addressed.

Smart Planning 01: Understanding TODs vs WUCs

Sometimes confused for being the same thing, Transit Oriented Developments (TODs) and Walkable Urban Centres (WUCs) are two distinctly different urban creatures. TODs create efficiencies of urban movement, such as reducing car dependency by providing proximity for residents and office workers to public transport infrastructure. WUCs sit at the heart of communities, providing mixed-use environments that foster social, economic and cultural productivity.

These and other projects give rise to a number of reflections on the subject of TOD design. These are not limited to the social, economic and environmental opportunities to be found in developing at close density to public transport nodes. Indeed, there are other significant concerns such as the physical relationship between TODs and WUCs. In particular, the mistake often being made is to assume that any TOD can also be an effective WUC.

The key challenge of rail-based TODs is that railway tracks and railway station buildings are large objects such that, unless carefully (and usually expensively) handled, get in the way of everyday urban movements. Large stations can block the flows of people through cities and railway tracks can sever movement routes. The addition of car parks and service routes adds further challenges to the maintenance of the two most important physical/spatial characteristics of WUCs:

a. *Seamless spatial linkage* in the form of continuously connected street networks, the spatial device that facilitates movement to, through and around centres

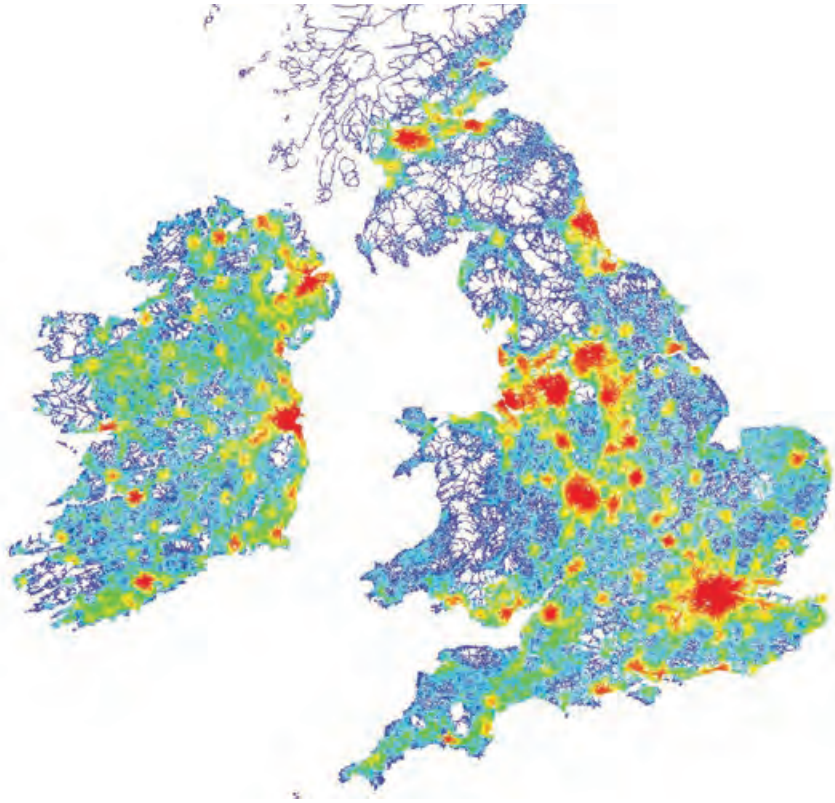
b. *Continuous active frontages* at street level that provide the architectural vehicle for land-use attractions to interface with moving people

As a result, TODs either need to be placed beneath or above those everyday urban flows or close to the continuously connected and animated flows of a WUC. The key questions can be framed around:

- **Density:** Is there enough density to justify the investment required to cover the tracks so that the urban centre can be integrated with the transit station? If not, the urban centre should be close to but not integrated with the transit station.
- **Connectivity:** How do the urban centre and the transit centre connect to each other? Whether directly above or close to each other, seamless connectivity is essential.
- **Integration:** How do the WUC and TOD integrate with their wider context? It is essential to have a walkable grid of streets that connect the WUC and TOD to all the other land uses around them.



This anaylsis of transit oriented developments shows movement patterns from transport to the surrounding land uses.
Image: Space Syntax



The Integrated Urban Model shows the potential of human activity and vibrancy based on the street network.
Image: Space Syntax

Smart Planning 02: Understanding Movement Flow and Pedestrian Activity

> The actual function of places—as opposed to their intended function—follows the flows set up by the spatial form of those places, independent of their designers' wishes.

Many places work in ways not originally intended. The artist's impression is often unrealised, with public spaces less well-used than in drawings, shops not getting the footfall shown in illustrations, tracks worn into green spaces painted as pristine in renderings.

The actual function of places—as opposed to their intended function—follows the flows set up by the spatial form of those places, independent of their designers' wishes.

It is risky to think that form follows function, and not appreciate that a place functions according to the flows shaped by its physical form. If this relationship is not understood, there is a high risk that urban layout structures will be designed inappropriately and end up with problematic functions.

With software that forecasts flows by analysing physical forms, and with design principles shaped by decades of experience, Space Syntax has been able to reduce risks from the design process. Physical city structures can be analysed, pedestrian flows simulated, and planners can anticipate the functioning of schemes at the earliest stage of design. They can then feedback the recommended changes in order to optimise flows and close the gap between intended and actual functions.

e ESSAY



PLANNING & GOVERNANCE
PETER HO

Peter Ho is Chairman of the Urban Redevelopment Authority (URA). This article is adapted from his keynote speech at the World Cities Summit 2021 webinar, Making Sense: Leveraging the Science of Cities, jointly organised by the Centre for Liveable Cities (CLC) and the Urban Redevelopment Authority.

Leveraging the Science of Cities to Solve Complex Urban Challenges



People and their interactions are part of the complex systems of cities.
Image: JC Gellidon / Unsplash

Cities are enormously complex.

In each city, every person, also referred to as an agent, interacts with each other and with the environment. These interactions are usually hidden from view and often unpredictable in nature. As a result, they can defy conventional analysis and produce outcomes that confound and astonish. How do we make sense of all of it?

> Outside the realm of the hard sciences, reductionism has not been very useful in predicting the holistic behaviour of complex systems like cities.

Cities as Complex Systems

To understand how a city works, we must understand not only the behaviour of each person living in it, but also how they interact with others, and how they behave as a whole. Given the state of science in the past, this would have seemed an enormous—even insurmountable—challenge. But the situation is changing.

The Challenge of Reductionism

For hundreds of years, the basic approach to understanding complex systems was *reductionism*. It reduces complex systems—like cities—into smaller and simpler parts that are easier to study, analyse and evaluate. Instead of studying cities as a whole, their complex problems are sliced and diced into digestible pieces such as functional areas like transport, environment, energy, public health, social dynamics, economics and so on. However, there is a flaw in this approach. The assumption is that when these smaller parts are reassembled, the whole will be approximate to the real world. Unfortunately, outside the realm of the hard sciences, reductionism has not been very useful in predicting the holistic behaviour of complex systems like cities, whether they will flourish or fail.

> Intervention in complex systems can lead to unforeseen and often undesirable outcomes.

Interdependency and Emergence

Chinese philosopher, Lao Tzu, once wrote that "everything is connected, and everything relates to each other". People as well as other agents are not independent. Instead, they are *interdependent*—interacting and influencing each other in ways that defy a deterministic or linear analysis. Their interactions lead to outcomes that are inherently unpredictable *ex-ante*, and are only revealed when they occur. In other words, we only know what is going to happen when it happens. This is the property of *emergence*, which characterises complex systems.

The Law of Unintended Consequences

As a result of emergence, complex systems are prone to the *Law of Unintended Consequences*. In other words, intervention in complex systems can lead to unforeseen and often undesirable outcomes.

In transport, for instance, traffic congestion, car accidents, air pollution and global warming are all unintended consequences of the advent and widespread adoption of the automobile.

Adopting an Interdisciplinary Approach

Thus, it is important to look at complex systems not just in terms of their component parts, but also as a whole.

However, for a very long time, investigating the features of complex systems like cities at a holistic level was eschewed



Rush hour traffic congestion—an undesirable outcome of complex urban systems.
Image: epSos.de / Wikimedia

in favour of investigating the properties of the components. It was easier and the scientific tools for analysis at that micro level were already available.

Part of the reason for this is that scientists have been conditioned over centuries of reductionism to dissect the complex world into smaller and less complex parts, and to favour explanations framed at the lowest level of scale.

However, in recent years, efforts to study the overall properties of complex systems have begun to attract interest. Pioneers in the field are now looking at problems of complexity holistically, acknowledging that the properties of higher-level entities like cities are often quite distinct and unrelated to those of the components that constitute them. This is a radical departure from studying problems within disciplinary silos. It is a holistic approach in which academic silos are collapsed in favour of interdisciplinary and integrative study.

Interdisciplinary study achieves a holistic understanding not by rejecting reductionism but by building on it. That combination of holism and reductionism makes it possible for interdisciplinary study to address the big challenges of today, including, of course, urbanisation.

In Singapore, as well as in countless cities around the world, the urban planning process considers the complexity of packing in housing, green space, industrial land, commercial and retail space, land for transportation needs, and other public infrastructure like hospitals and power stations. This process involves integrating the perspectives of economic, social and development agencies, as well as consultations with various stakeholders in the private sector and the general public. This Whole-of-Government approach is in essence an interdisciplinary approach to planning that enables all stakeholders to better understand interdependencies and implications of land use and strategic decisions.



Artist's impression of Singapore's first smart and sustainable town in Tengah.
Image: Housing & Development Board (HDB), Singapore

> Cities are often quite distinct and unrelated to those of the components that constitute them.

New Tools for the Science of Cities

Paving the way ahead are complexity science tools, such as agent-based modelling, which examine how agents in a complex system interact with one another and influence system behaviour. These tools, when applied to cities, are beginning to provide fresh and useable insights that deterministic models have failed to produce.

To explore how such tools can be used in Singapore's context, government agencies are conducting research and acquiring confidence in the utility of these tools. This is a major step towards establishing a science of cities as a foundation for urban planning.

The Emergence of Big Data

Furthermore, the availability of data to assist in the quantitative study of cities has grown significantly in recent years. There is so much data being generated now that the amount of data created over the next three years will be more than the data created over the past 30 years.

The agents within a city—the people, public and private institutions, markets and networks are all contributing to what we now refer to as *big data*. The key difference is that we now have the technology both to capture big data, as well as to process it.



Artist's impression of Singapore's pilot polder development at Pulau Tekong.
Image: HDB, Singapore

Singapore's Smart Nation initiative is in essence an exercise to systematically capture this big data. When combined with high performance computing, increasingly powerful data analytics, and Artificial Intelligence, such big data can be converted into useful insights into new patterns and trends. This is a truly powerful capability that is vital to the development of the science of cities.

The tools of complexity science combined with the insights from big data can help us to "see" the city through new lenses. What then are the fresh possibilities to imagine and shape a different and better city for the future? More importantly, if we can imagine a different city of the future, we can take active steps toward realising it. This is what a good science of cities should be able to achieve.

Emergence of a Science of Cities in Singapore

In Singapore, there is no shortage of research into urban matters. The Lee Kuan Yew Centre for Innovative Cities, the Singapore-ETH Centre's Future Cities Laboratory, the Lee Kuan Yew School of Public Policy and a host of other university-based centres, laboratories and institutions study aspects of the urban setting. The next step is to integrate such research—combining the reductionist with the holistic. In time, this will evolve into the science of cities. Already in Singapore, the Centre for Liveable Cities (CLC) is taking the lead to integrate the efforts of these various research institutes, using new tools of complexity science.

Embracing Experimentation

With complex systems like cities, exploration and experimentation are often more valuable than relying

> There needs to be a willingness to try things out, to experiment with new approaches and solutions.

on predictions of analytical models. There needs to be a willingness to try things out, to experiment with new approaches and solutions. The approach is to probe, sense patterns and to act, even in the absence of complete information. Pilot programmes, demonstrators, prototypes and "beta versions" should be embraced as a foundational approach to deal with complex systems. If they work, they are evidence that the hypothesis can be scaled up. If they fail, the damage is mitigated.

In Singapore, this approach is adopted for some complex urban challenges. For instance, polder development is being piloted at one of its islands, Pulau Tekong, where land is being reclaimed in a sustainable manner and at lower cost. The polder technology can also be an adaptation measure for future sea level rise due to climate change. Elsewhere, whole districts such as the Punggol Digital District for the smart digital economy and Tengah for sustainability will be living laboratories for researchers and companies to pilot new ideas and solutions, and for people to explore and embrace new lifestyles.

In 2016, a floating solar farm was test-bedded at Tengeh reservoir in western Singapore. With its success, the pilot was scaled up 60 times to create one of the world's largest floating solar farms. This will power our local water treatment plants, making Singapore's waterworks one of the very few in the world to go 100% green.



Punggol Digital District is designed to enable collaboration between industry and academia through the sharing of each other's spaces and facilities.
Image: JTC



Floating solar farm at Tengeh Reservoir.
Image: Sembcorp Industries

Conclusion

As Geoffrey West, the distinguished theoretical physicist at the centre of efforts to develop a science of cities, observes, the future of humanity and the long-term sustainability of the planet are inextricably linked to the fate of our cities. This is a compelling reason to develop a science of cities that provides a framework for understanding how they work, as well as what drives their growth sustainably.

Many of the building blocks for the science of cities are already in place. The tools of complexity science are steadily improving; big data, as well as the technology to collect and analyse it are now available. With the long experience in studying cities at the component level, the next step to take is to study them holistically.

Lastly, beyond taking an interdisciplinary approach, fostering partnerships among companies, government agencies and communities in pilots and strategically-directed research funding are also key.

With the assembly and integration of these different building blocks, we can look forward to discovering new possibilities and knowledge that can lead to the development of better plans and policies to ensure Singapore's future liveability and sustainability.

ILLUSTRATION

DATA VISUALISATION

Visualising the Science of Cities

TEXT: GARETH CONCEICAO & ERWAN XIAO

Data visualisations of a city and its systems are essential for understanding a city and its challenges. These visualisations range from 19th Century sketches and drawings to today's 3D-modelling and dynamic mapping. Moving beyond the purposes of architecture and land-use planning, these visualisations provide a lens on social, health, economic and environmental challenges in cities, galvanising change in planning and policy.

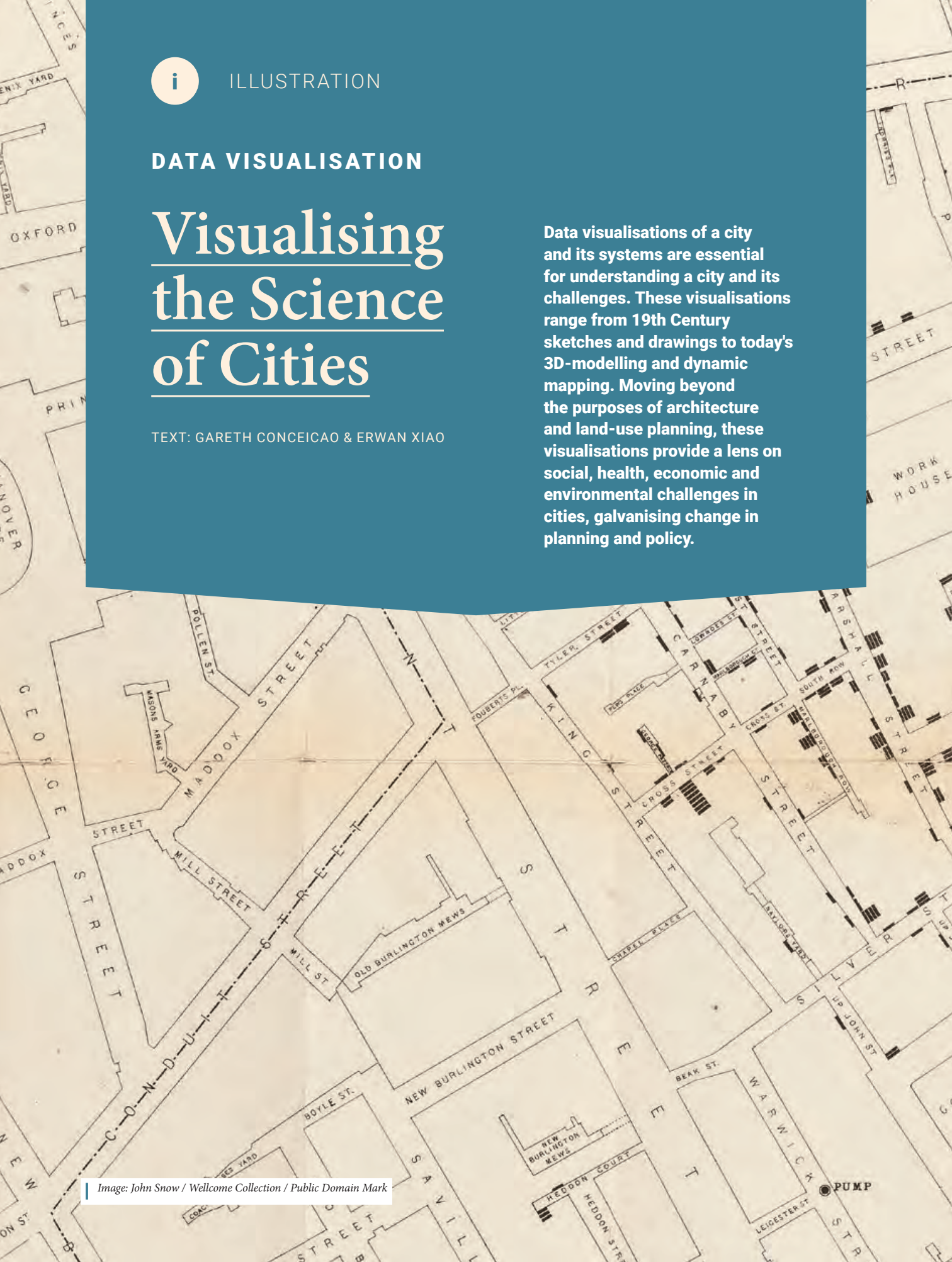


Image: John Snow / Wellcome Collection / Public Domain Mark



1854 Broad Street Cholera Outbreak

This map, by Dr John Snow, is an early example of using data visualisation for analysis. It mapped the location of deaths from cholera during the 1854 Broad Street outbreak. Most of the deaths were found to have been clustered around the water pump on Broad Street, which led to the removal of the pump handle. The map was influential in the field of public health, and helped change the understanding of disease (before germ theory was well established).

Causes of Mortality in the Crimean War (1853–1856)

Florence Nightingale's 1858 data visualisation of the causes of death in the Crimean War revealed that the majority of deaths were due to disease from poor hospital conditions. These were presented by "red" for wounds, "blue" for disease and "black" for all other causes.

Nightingale used the data to report on and campaign for improved living conditions in the army.

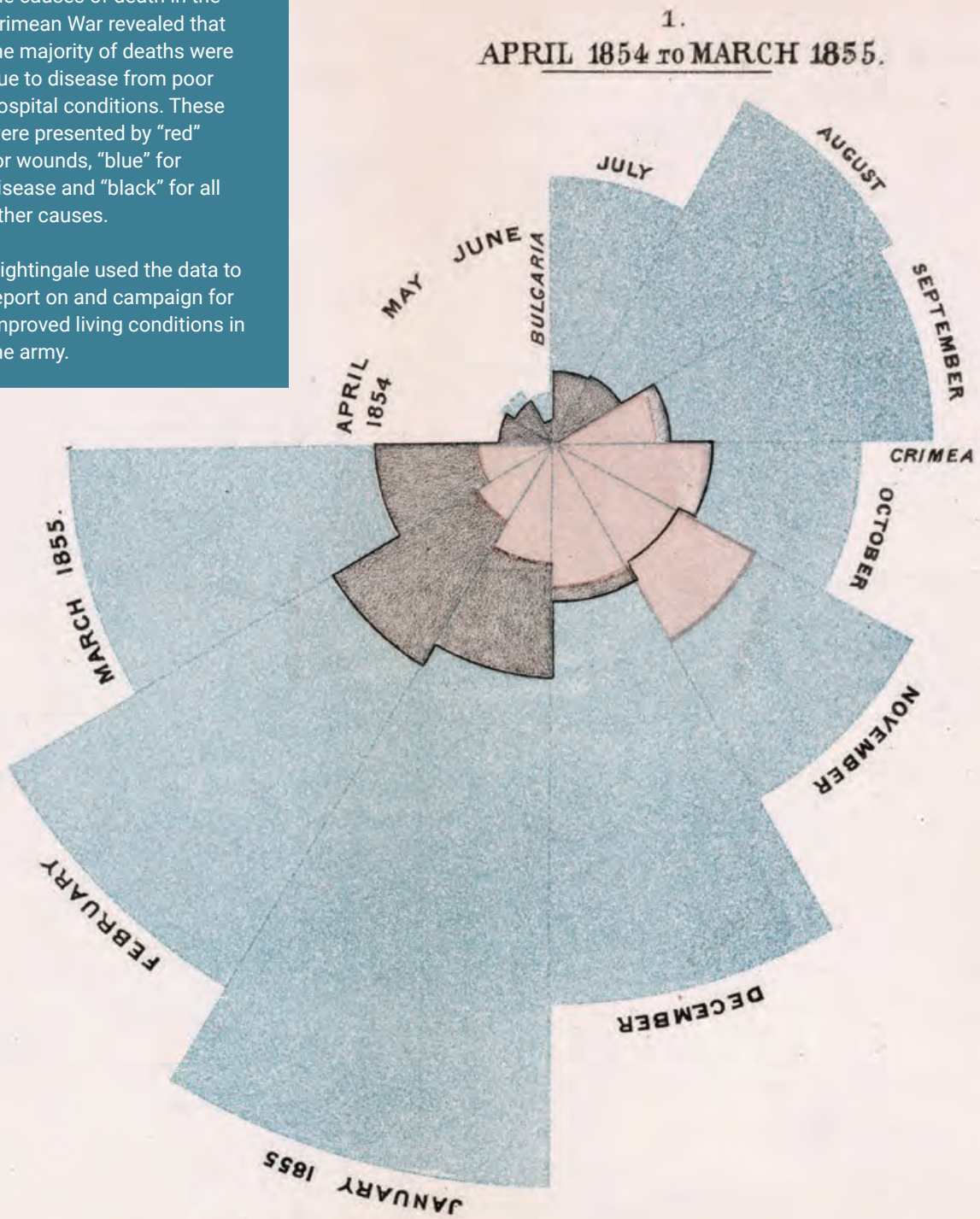


Image: Florence Nightingale / Wikimedia / Public Domain

Visualising the Effects of Sea Level Rise on Singapore

A rise of 1 m in sea levels would heavily impact Singapore. This visualisation was used by the Prime Minister Lee Hsien Loong at the 2019 National Day Rally as a call for collective and urgent action to address climate change.



Image: Prime Minister's Office, Singapore

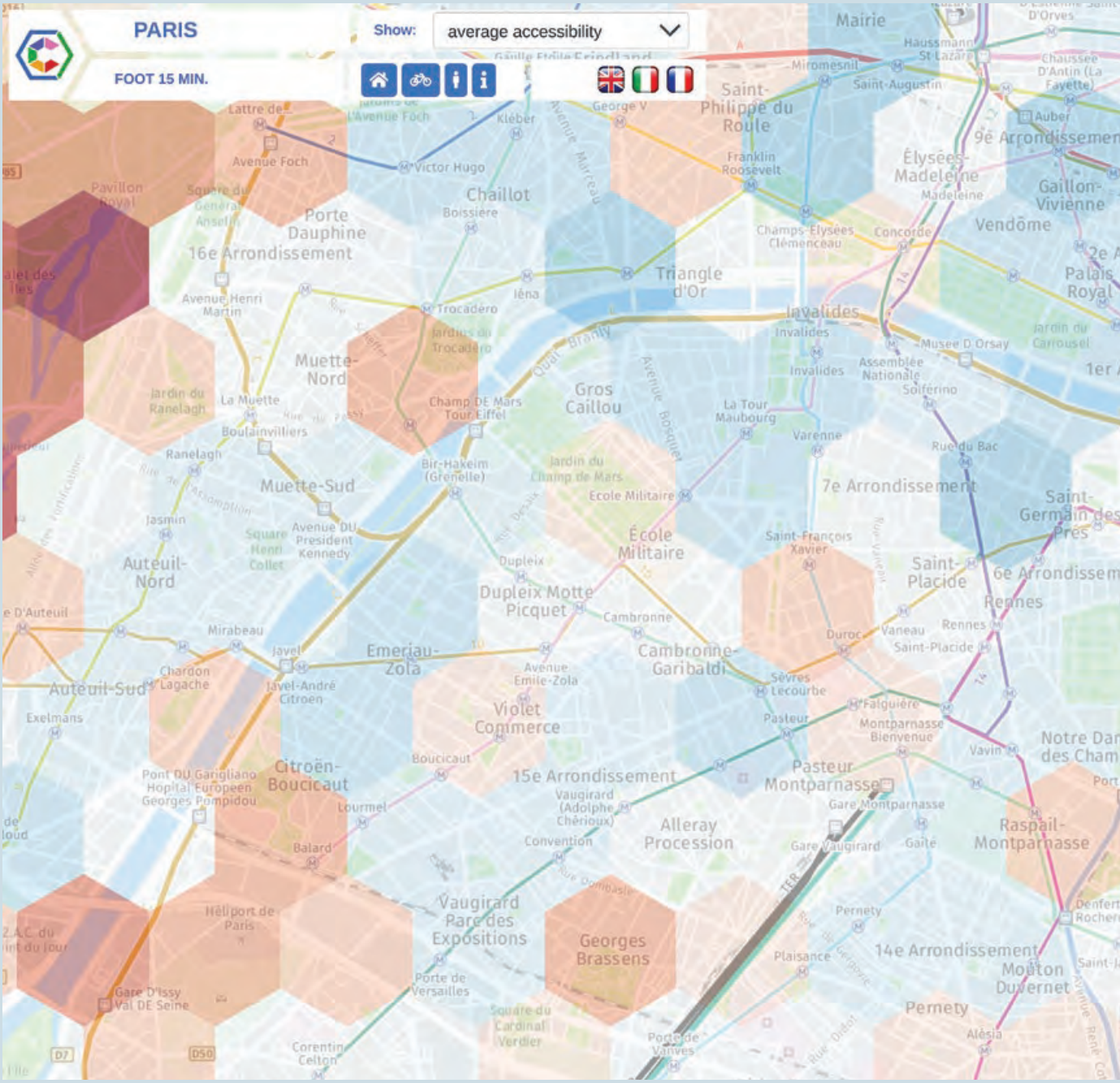
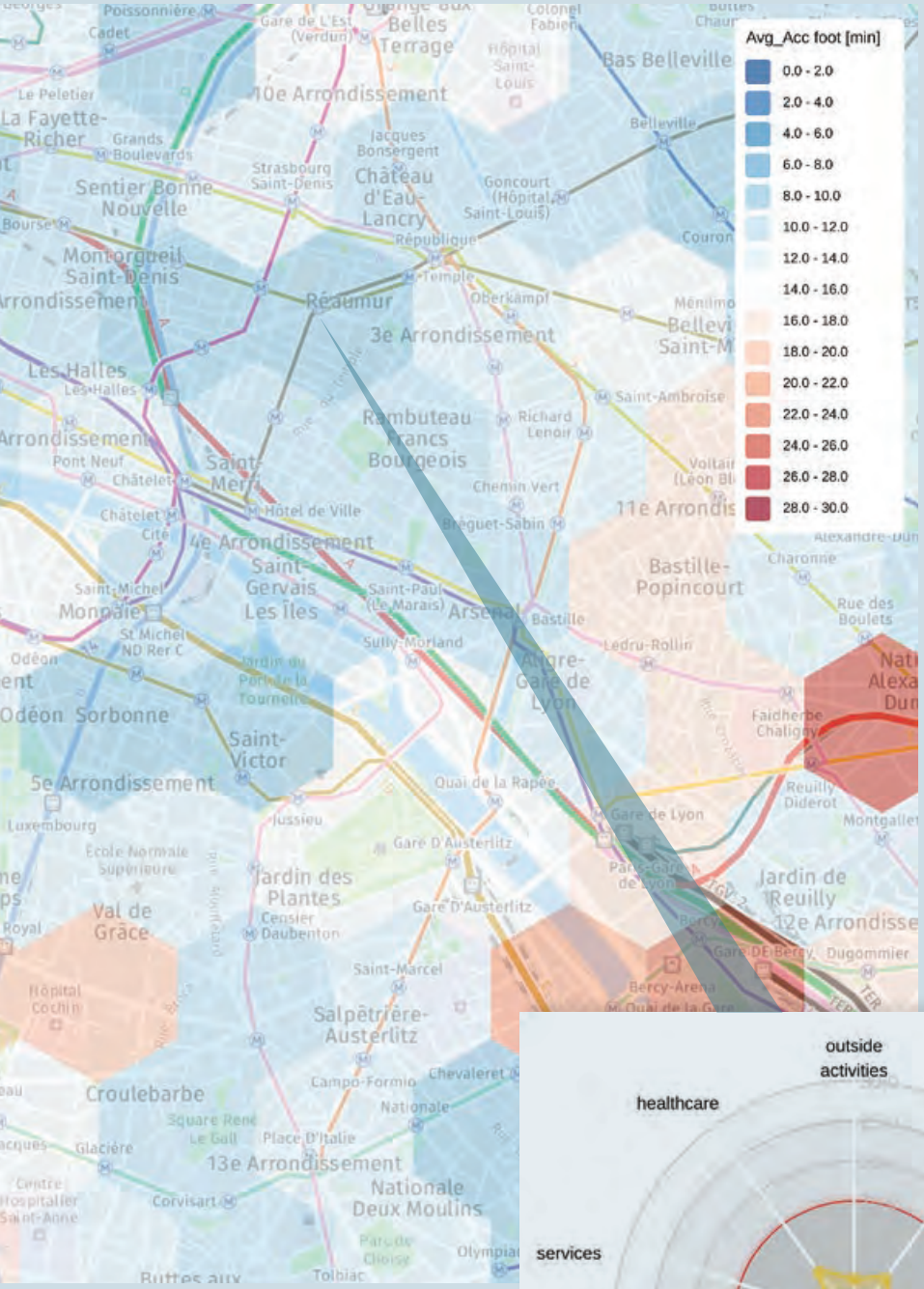


Image: 15-Minute City / Sony Computer Science Laboratory, Paris



15-Minute Cities

The 15-minute city, first proposed by Carlos Moreno and popularised in Paris, describes an urban layout of liveable dense cities by decentralising a city and making all of a resident's needs accessible within a 15-minute walk or bike ride. The map rates different areas of Paris on how well they fare based on this ideal. Blue zones have more amenities that are within a 15-minute walk, while red zones have less.

This concept of designing cities and neighbourhoods centred on walking and biking has caught on and is being implemented around the world, in cities like Singapore, Shanghai, and Melbourne, with varying parameters of time.



Poverty Map of London

Charles Booth's poverty map of London in 1889 highlighted that the poor were not solely responsible for the conditions they were in: poverty in cities had a spatial and environmental context, beyond the traditional health context. The maps offered a manageable way of dealing with clusters of poverty when no other forms of visualisations were available.

His findings also led to increased campaigning for social policies such as the introduction of old-age pensions and formal structures of labour, as most of the poor had inconsistent incomes leading to their constant state of poverty.

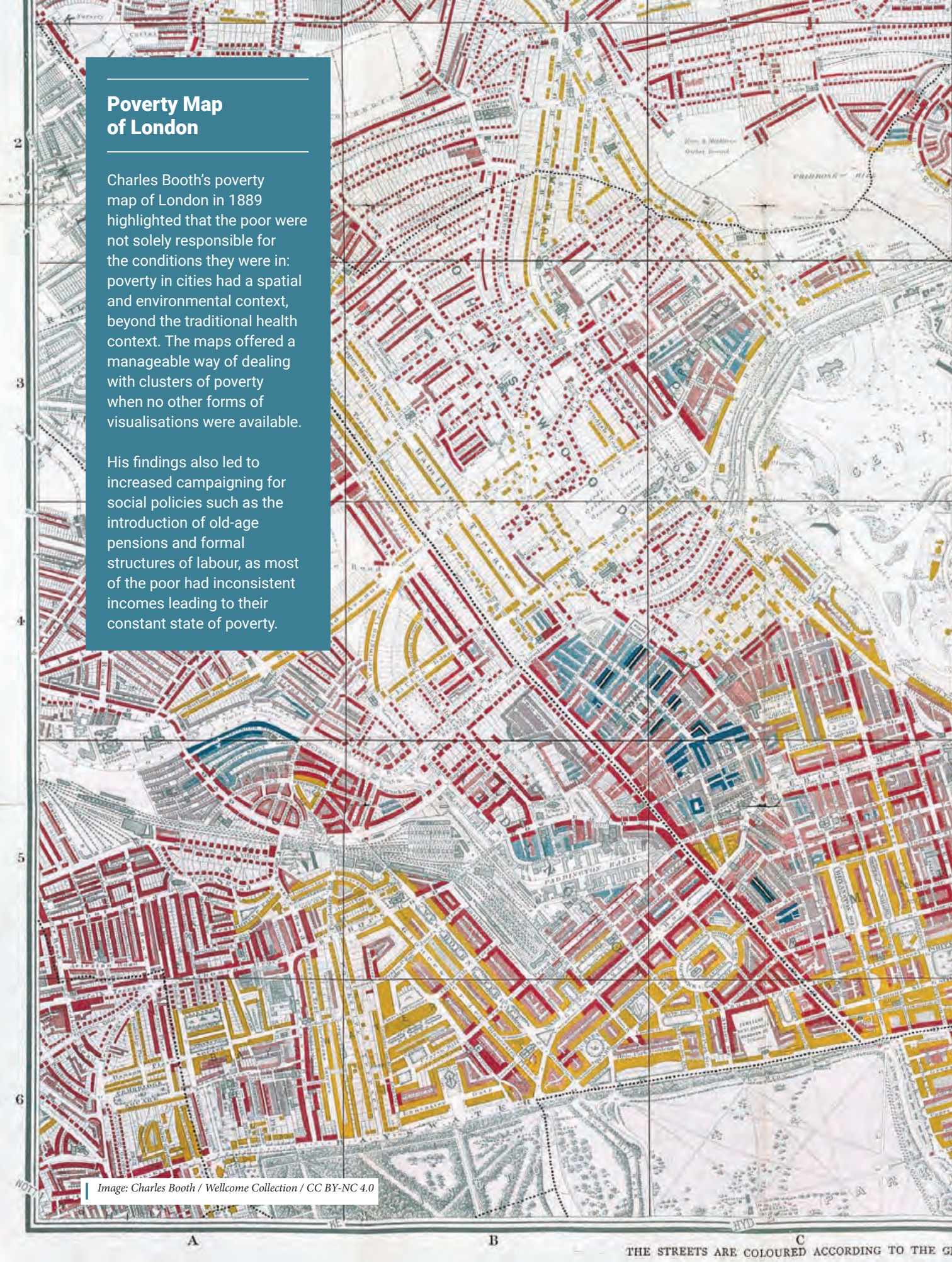
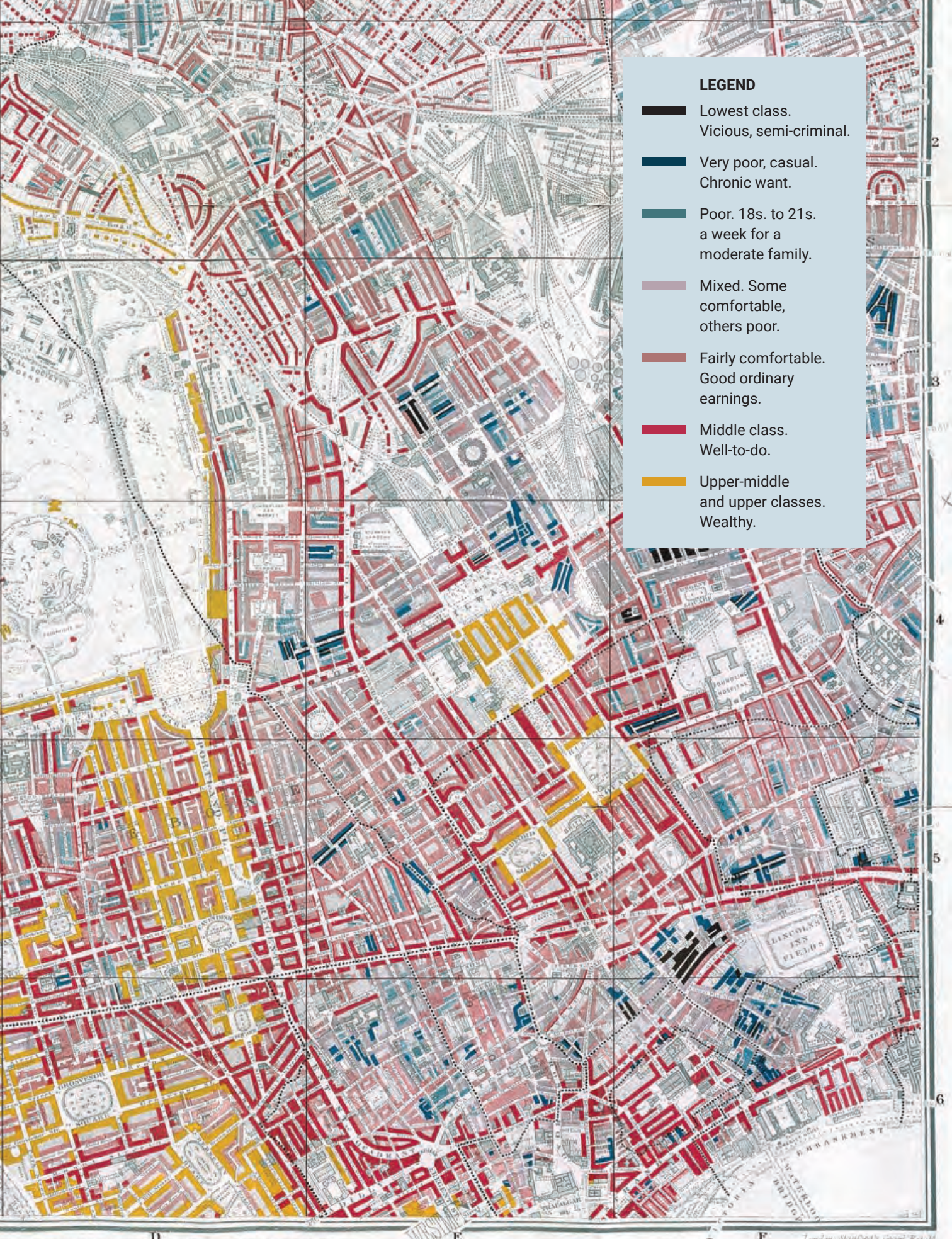


Image: Charles Booth / Wellcome Collection / CC BY-NC 4.0

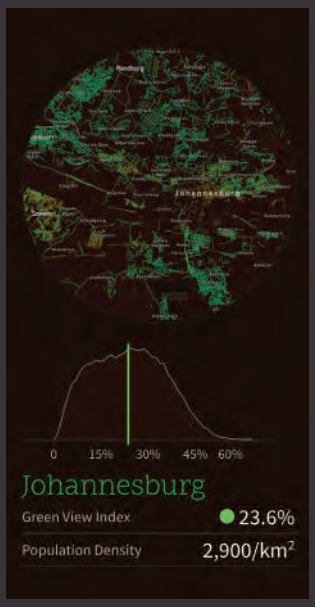

LEGEND
Lowest class.
Vicious, semi-criminal.
Very poor, casual.
Chronic want.
Poor. 18s. to 21s.
a week for a
moderate family.
Mixed. Some
comfortable,
others poor.
Fairly comfortable.
Good ordinary
earnings.
Middle class.
Well-to-do.
Upper-middle
and upper classes.
Wealthy.
D
E
F
ENERAL CONDITION OF THE INHABITANTS, AS UNDER:—

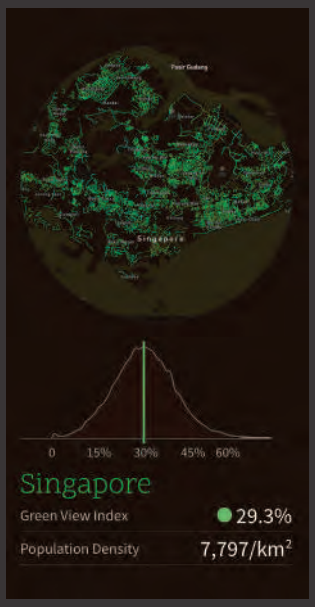
Treepedia–MIT Senseable City Lab

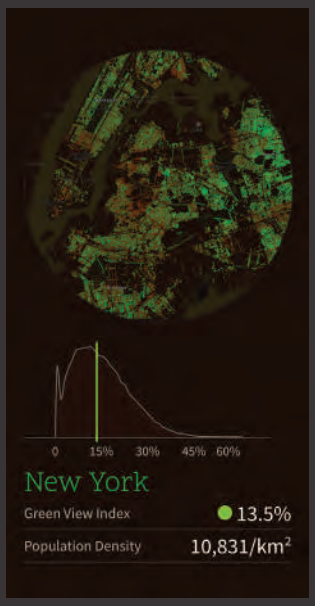
Treepedia visualises the green canopy of cities, using panoramic views of Google Street View and mapping them as an index, allowing efforts of greenery intensification to be compared across cities.

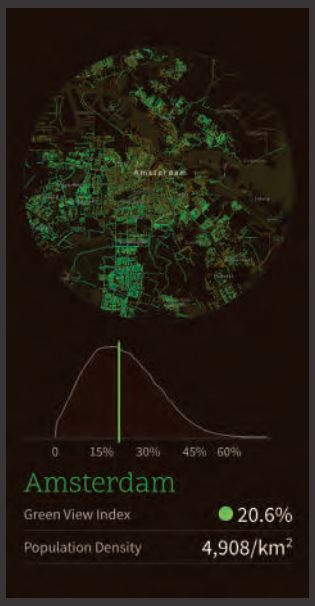
Increasing green canopy in cities is one of the priorities in urban cities due to rapid urbanisation and the consequent increase of urban-heat.

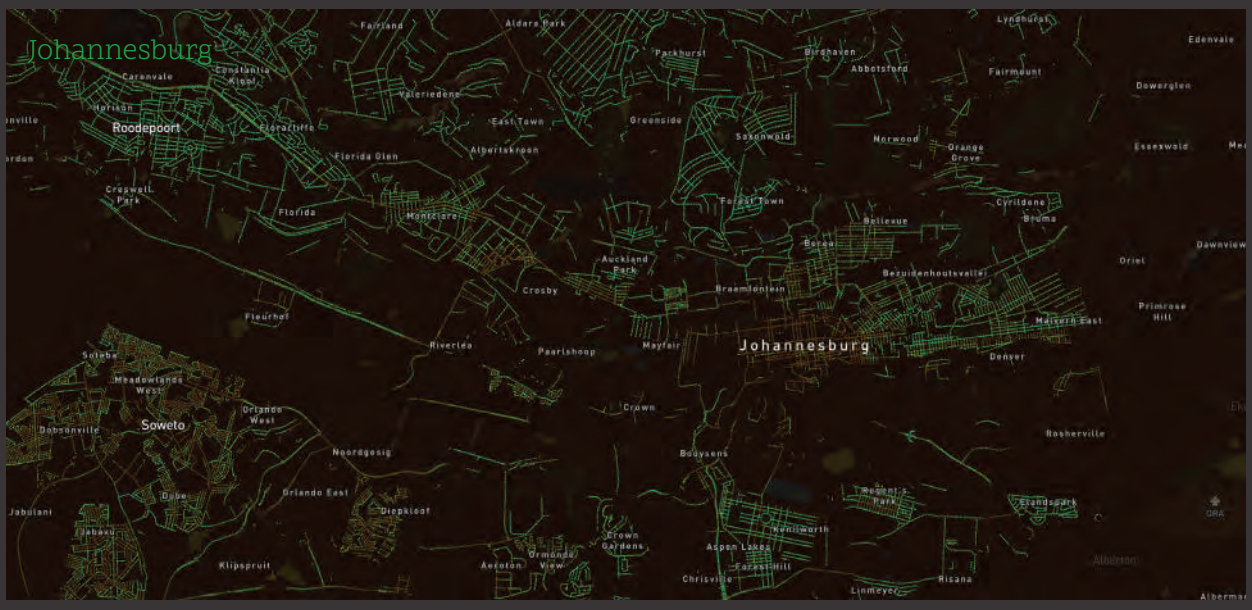
Images: MIT Senseable City Lab



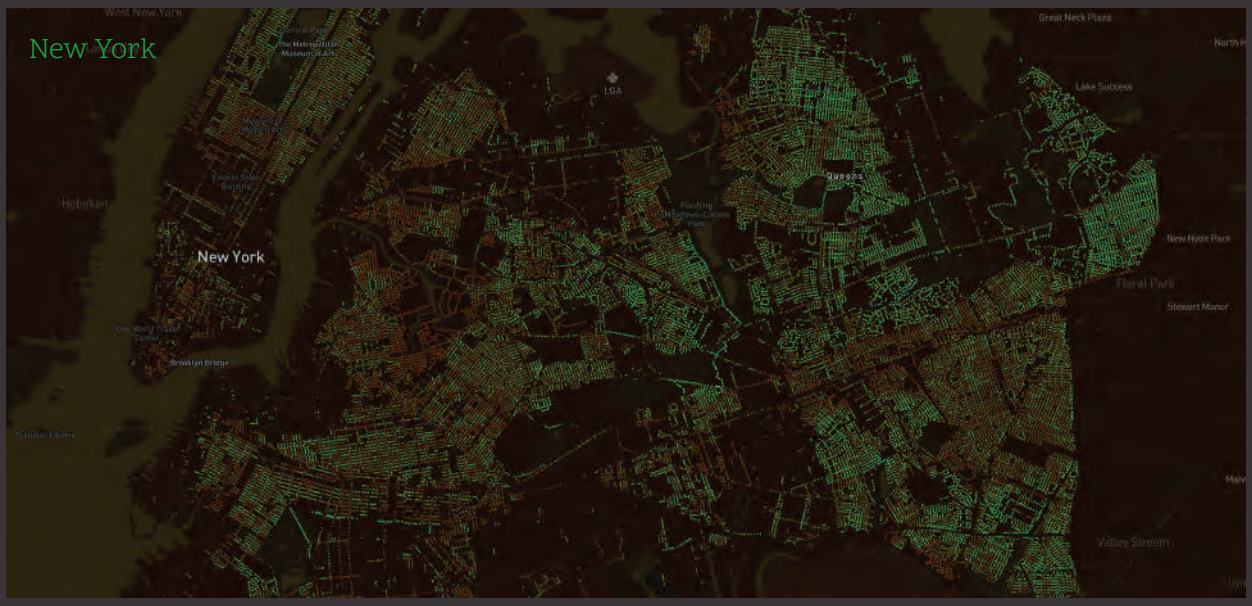


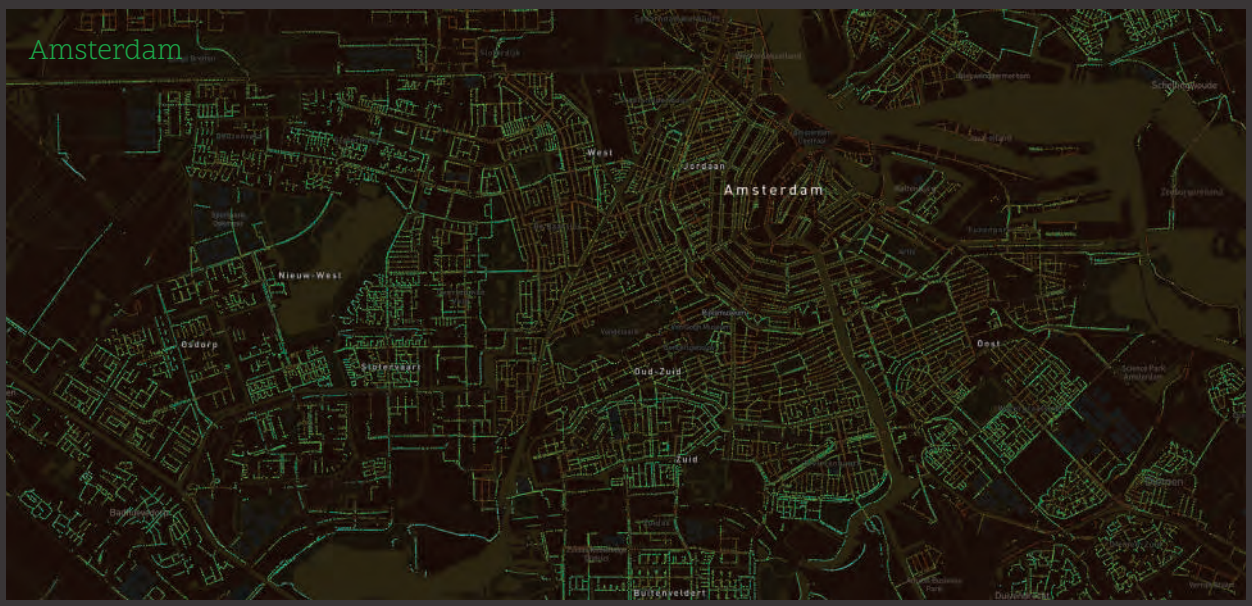







Singapore
Pasir Gudang
Iskandar Puteri
Singapore


New York
West New York
Great Neck Plaza
Lake Success
LGA
Queens
Hoboken
New York
New Hyde Park
Floral Park
Stewart Manor
Brooklyn Bridge
Valley Stream


Amsterdam
West
Jordaan
Amsterdam
Nieuw-West
Osdorp
Oud-Zuid
Oost
Zuid
Buitenveldert

C CASE STUDY

MELBOURNE | TRANSPORT

Orbiting Melbourne: The Case for Improving the City's Mobility

As Melbourne grows, it will need an infrastructural facelift to keep up with population and employment growth—especially as economic shifts disperse jobs within and beyond the city centre.





Keval Singh was formerly a Senior Content Strategist at Tuber, the editorial consultancy for Urban Solutions.



The rail network is essential in providing Melburnians with access to jobs, services, schools and parks.
Image: Arun Clarke / Unsplash

> **Accessibility to these opportunities, and public transportation, is thus essential.**

The Challenge

The Australian city of Melbourne has witnessed rapid development over the last two decades, an ongoing trend reflective of broader changes in its home state of Victoria. The state has seen economic growth driven primarily by population growth and structural change towards a more diverse, knowledge- and service-based economy.

A report by the Suburban Rail Loop Authority (SRLA) notes that this structural shift in Victoria's economy has influenced where different types of jobs are located across Melbourne. Broadly speaking, there is significant clustering of employment in the central city, with employment in the suburbs highly dispersed (see Box 1). Accessibility to these opportunities, and public transportation, is thus essential.

Box 1: Distribution of jobs across Melbourne

- Knowledge-based sectors: concentrated in the central city and inner suburbs due to superior accessibility and connectivity
- Industrial businesses: precincts in the outer west, north and south
- Education, training, health and businesses: dispersed across Melbourne

The city is currently connected via a radial rail network, with all lines leading to the City Loop, which gives commuters access to all corners of the CBD.

> **These activations can therefore bring renewed use and life to underused or overlooked spaces, provide interim uses on land earmarked for future redevelopment and enhance a wide range of other spaces within the precincts.**

With trams also running through inner city suburbs, Melburnians living close to the CBD enjoy excellent public transport connections and have easier access to high-value jobs. Those outside the inner ring—along the rail network or close to a tram stop—would not be terribly far behind.

The problem lies beyond these areas, where access to the city centre by mass rapid public transport is limited, and people are forced to use cars to commute to work. This situation is only set to worsen in the coming decades with population growth.

By 2056, Melbourne is expected to be a city of 9 million people—around the same size as London today.

Further, not all Melburnians travel to the city centre for work. Many are employed in jobs dispersed throughout the suburbs or emerging economic clusters. A substantial proportion of people lives and works within the same ring. As seen in Fig. 1, for example, 79% of those living in the outer ring work there as well. They would thus need to travel orbitally around Melbourne, rather than radially from the suburbs into the central city.

The Solution

In accordance with *Plan Melbourne*, the government's long-term planning strategy for the city to remain a global city of opportunity and choice, Suburban Rail Loop (SRL) will help reshape Melbourne into a city of centres. Suburban Rail Loop will be the city's first orbital rail line: a 90 km stretch that will run through Melbourne's middle suburbs, with links to every existing rail line and Melbourne Airport. SRL will be delivered in stages: SRL East from Cheltenham to Box Hill, SRL North from Box Hill to Melbourne Airport and SRL West from the airport to Werribee.

Through the development of the broader areas around each station, SRL will help deliver the services, amenities and infrastructure Melbourne would need outside of the CBD and inner city. For example, it would create "transport super hubs" in the suburbs of Clayton and Broadmeadows. These will be located along SRL East and SRL North, shown in Fig. 2.

SRL will deliver the Victorian Government's higher-order objectives as articulated in *Plan Melbourne* by:

- Creating a "city of centres": The integrated transport, land use and precinct development approach will reshape Melbourne as a polycentric city, supporting the population, and economic and job growth in major centres beyond the central city.
- Providing a transport network for the future: SRL will create high quality polycentric and orbital transport connections, transforming how Melburnians travel across and around the city.
- Developing a local city: SRL will encourage "local living" and 20-minute neighbourhoods by supporting more local journeys and consolidating jobs, services and housing in accessible, attractive precincts.
- Increasing connections and opportunities for regional Victoria: SRL will improve connections between parts of regional Victoria and Melbourne's middle ring and Melbourne Airport.

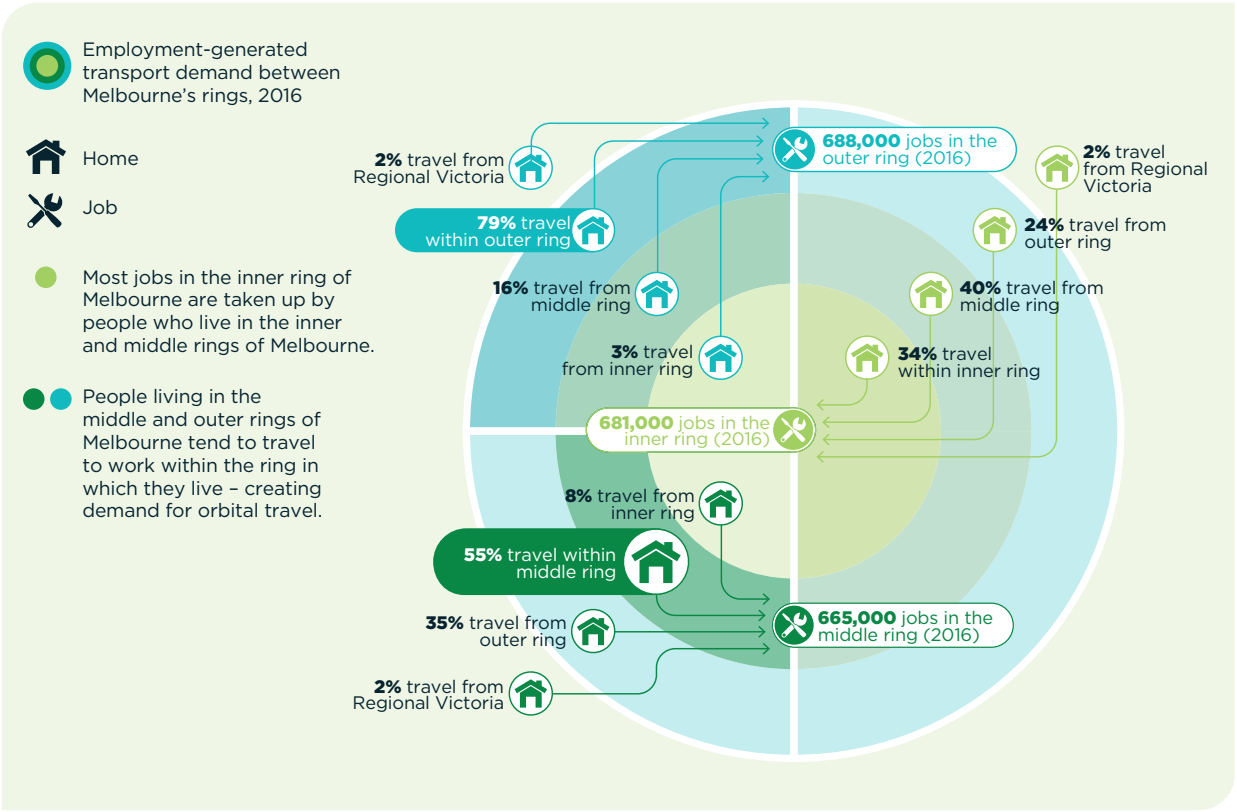


Figure 1: Employment-generated transport demand between Melbourne's rings, 2016.
Image: SRLA, Australia

A range of public and private sector organisations will be responsible for delivering broader precinct infrastructure to fully realise SRL's objectives. The Victorian Government, through SRLA, will partner with local governments and the private sector to enable integrated planning and delivery of legacy social and community infrastructure.

To do this, the Wellbeing Valuation approach has been used. It employs econometric techniques to estimate the Life Satisfaction created by a particular non-market good and converts this into a monetary value by combining it with an estimate of the effect of income on Life Satisfaction.

This approach provides a quantified indication of the social value of SRL, which includes benefits from improved social connectedness and well-being, together with increased diversity in jobs in the SRL precincts. "This reflects a trend we are seeing across the Asia-Pacific region, where governments are looking to leverage infrastructure investment to drive targeted and effective social equity and well-being outcomes," says Sarah Alexander, who is the Asia-Pacific Regional Solutions Director for Strategic Consulting at Jacobs, an engineering consultancy.

SRL will be delivered over multiple decades, with initial and early works for SRL East to commence in 2022. The decades-long timeframe for the construction of SRL is considerably longer than most infrastructure projects due to its scale and complexity.

Given the long delivery timeframe, there are opportunities for precinct activation. This refers to a wide range of short- and longer-term

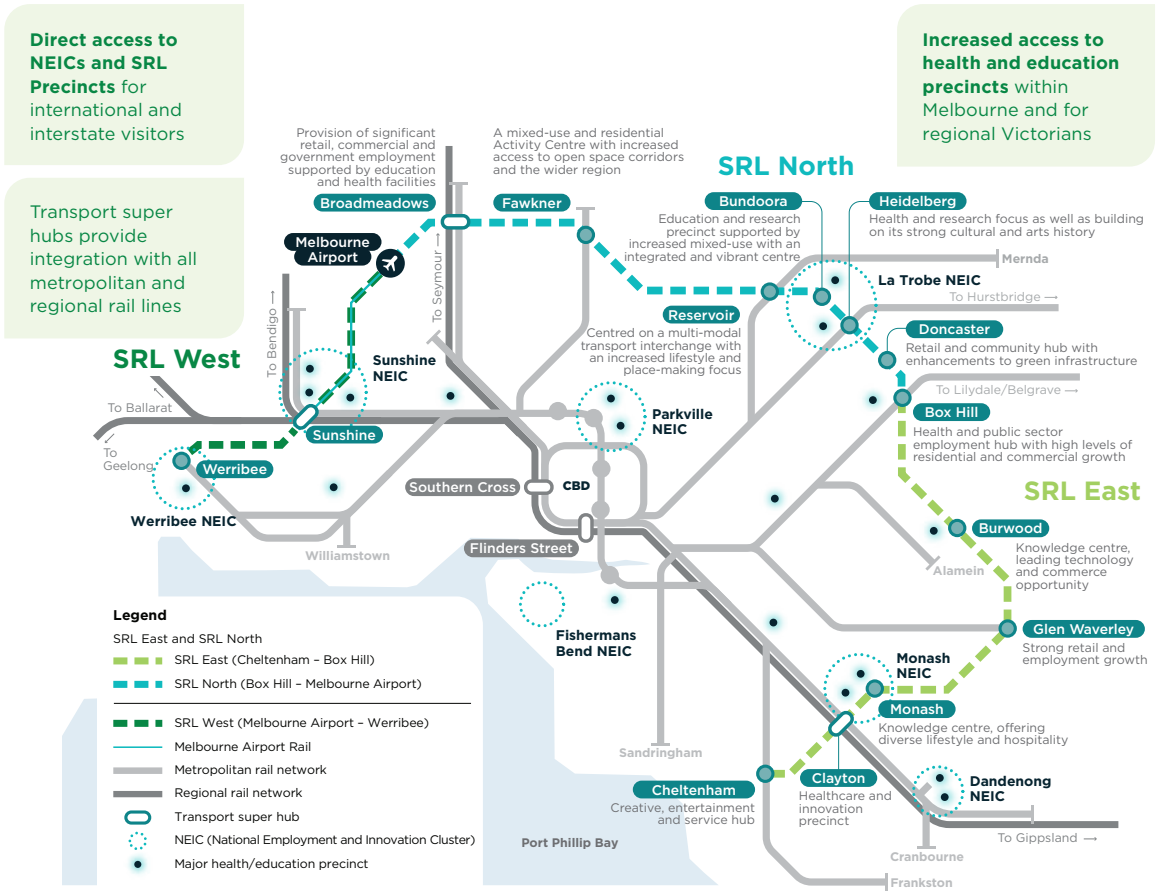


Figure 2: Recommended rail corridors on the Suburban Rail Loop network plan.
Image: SRLA, Australia



A Suburban Railway Loop station (artist's impression).
Image: SRLA, Australia

projects that seek to provide public benefit and make productive, connected and liveable precincts. These can be pursued before and during the construction phase of the rail line.

For example, initiatives taken as part of SRL East will look to optimise and enhance key sites within the precincts. They will also engage and support communities and stakeholders to ensure a place-focused approach throughout SRL's delivery.

These activations can therefore bring renewed use and life to underused or overlooked spaces, provide interim uses on land earmarked for future redevelopment and enhance a wide range of other spaces within the precincts.

> SRL is a programme of works and initiatives that will shift Melbourne's urban form and social life.

The Outcome

SRL is not a standard transport project: it is multi-generational, transformative, city- and state-shaping. It will take time to deliver but its benefits are significant and long-lasting. The social value analysis for SRL East and SRL North focused on measuring the three well-being impacts are described in Box 2.

Box 2: Three well-being benefits for Melburnians

Improved sense of safety in the neighbourhood
A range of factors, including increased economic activity and access to public green open spaces, can help improve the sense of safety within a neighbourhood.

Improved sense of belonging
When a person has a sense of belonging, their overall well-being and life satisfaction is likely to improve.

Shift to more productive jobs
With a greater diversity of jobs, people can find pathways to more productive or higher-skilled jobs. This not only reduces incidences of skills mismatch or less productive work, but also provides greater life satisfaction to a person.

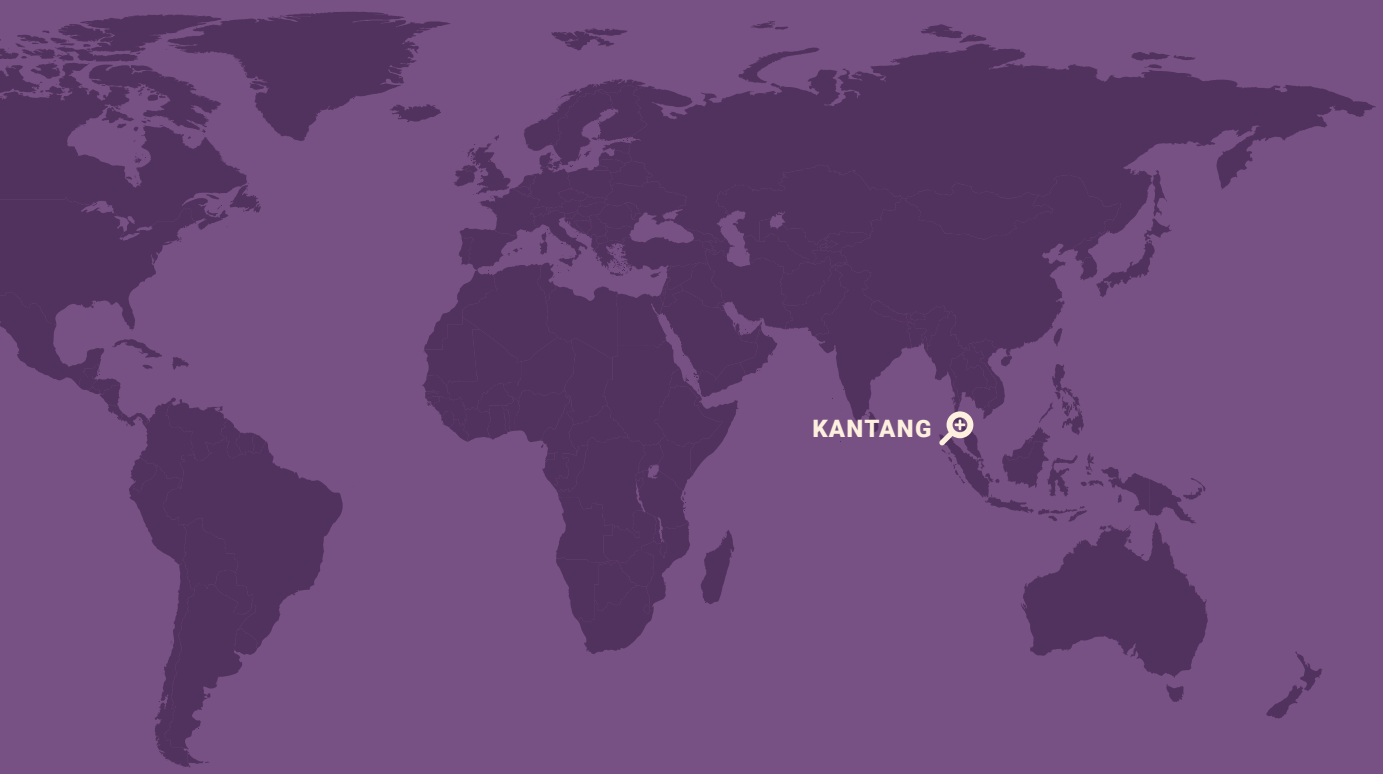
Realising *Plan Melbourne*'s vision requires more than just reacting to waves of demand; there is a need to plan ahead to shape where and how that demand materialises. "The past two years have shown us the benefits of living locally and having good access to open space and services within a short distance. The Suburban Rail Loop won't only change the way we move around the city, it will help build great communities with better access to quality jobs, services, schools and parks," says Frankie Carroll, the CEO of SRLA.

At its core, *Plan Melbourne* advocates for infrastructure investment that has the power to fundamentally reshape the city. SRL is a programme of works and initiatives that will shift Melbourne's urban form and social life. SRL will also ensure Melbourne's transport system is up to the task in the coming decades and will support Melbourne to become a more consolidated and sustainable city.

THAILAND | CIRCULAR ECONOMY

Thailand's Plastic Waste Problem and Its Road to Zero Plastic Waste

Thailand is said to be among Asia's biggest consumers of plastic. A lot of it ends up as waste in the environment. But the government is hoping to change this. We take a look at the opportunities and challenges that present themselves in Thailand, from both top-down and bottom-up approaches.





Keval Singh was formerly a Senior Content Strategist at Tuber, the editorial consultancy for Urban Solutions.

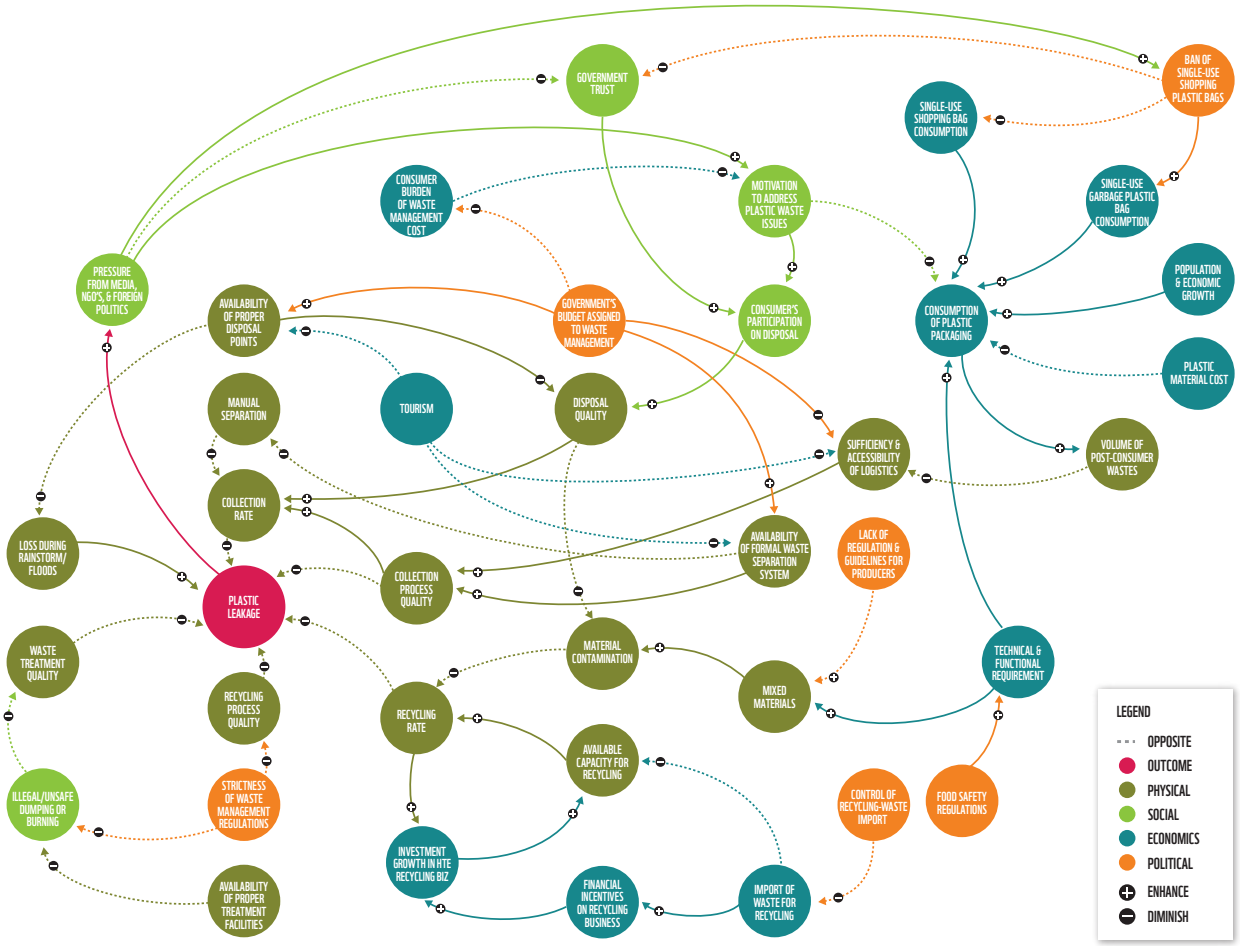


Figure 1: A systems map shows how complex, and yet inexhaustive, the underlying root causes of plastic waste can be.
Image: Metabolic

> The world has seen plastic production balloon from 2 million tons to 348 million tons per year over the last 65 years.

The Challenge

The world has seen plastic production balloon from 2 million tons to 348 million tons per year over the last 65 years. This includes a steady growth of plastic packaging. While it has clear benefits like reducing food waste and durability, the plastic waste that ends up in the environment is detrimental to human health and nature.

One country facing this problem is Thailand, where per capita consumption of plastic is among the highest in Asia. The country sees a 7% to 8% annual increase in plastic use attributed to Thailand's population growth and economic development.

According to a report by Metabolic, a Dutch consultancy on sustainability and the circular economy, around 80% of Thailand's plastic waste consists of single-use plastic bags. The COVID-19 pandemic has added to this trend: among other things, businesses have tried to regain consumers' trust by wrapping all products in plastic. Much of this ends up in the environment, especially marine ecosystems.

Figure 1 points to a variety of root causes of the plastic waste crisis. While not exhaustive, they demonstrate how seemingly unrelated factors result in increased plastic waste and litter.

> Over 60% of bags are improperly disposed of or leaked into the environment.

Some Reasons for Thailand's Plastic Waste Crisis

- **Political:** The Thai government has historically focused on dealing with water and sewage issues rather than waste. There has been a change in focus in recent times, but this too was impacted by the COVID-19 pandemic.
- **Economic:** The low priority focus on plastic waste means limited resources for waste collection schemes, which in turn result in low service coverage and collection rates.
- **Social:** Thai households often do not know which materials are recyclable and may not sort their waste properly, compounding the challenges to effective waste collection.

The Solution

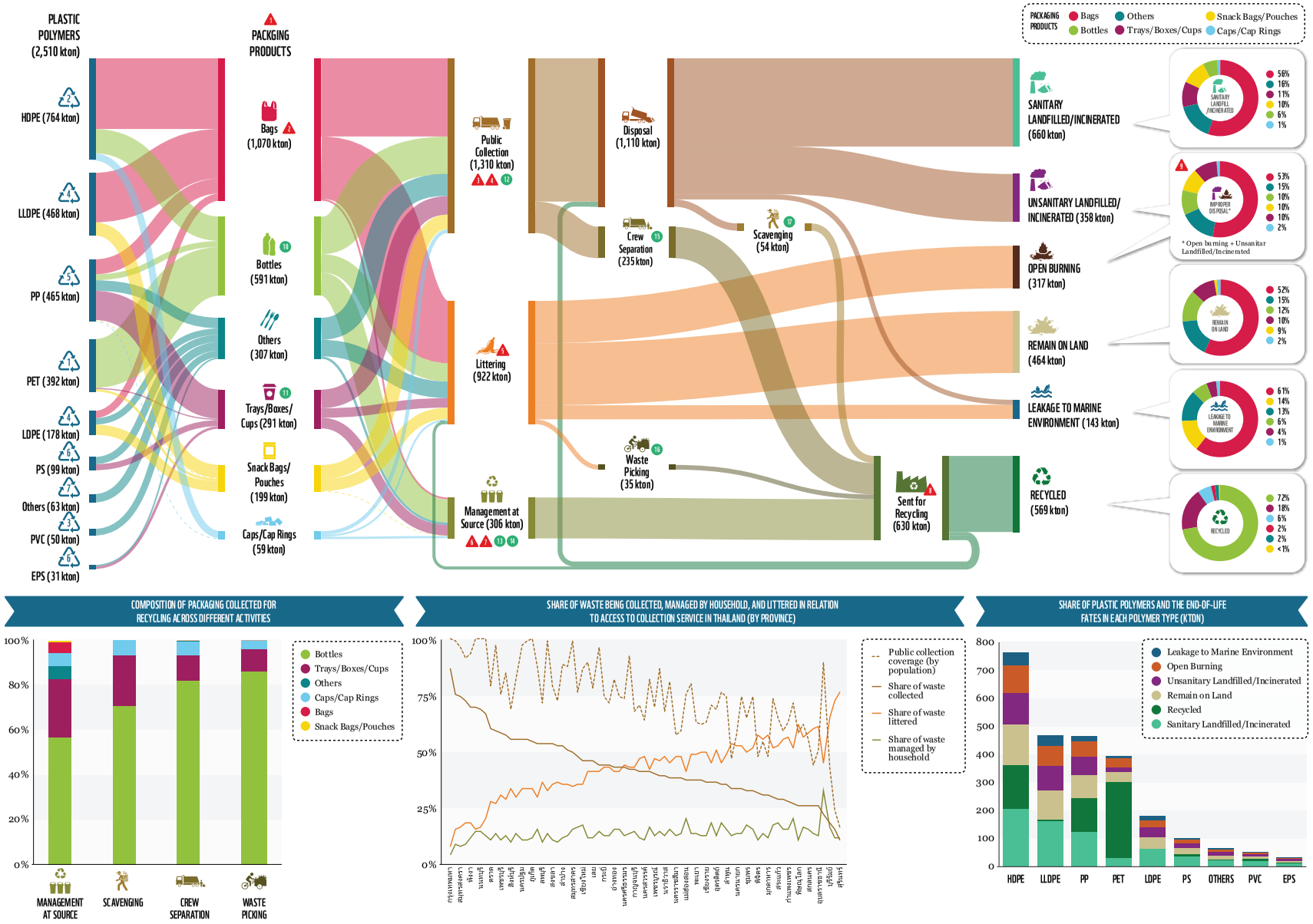
The Thai government, private sector and civil society are making efforts to curb the ever-growing consumption and disposal of plastic. At the national level, the government has adopted what has been called the Roadmap on Plastic Waste Management 2018-2030. It is being championed by the Ministry of Natural Resources and Environment, Department of Environmental Quality Promotion, Pollution Control Department and PPP Plastic (a public-private partnership including some of the largest plastic producers).

The roadmap lays out ambitious targets, including the development of a plastic waste recycling system that follows circular economy principles. This will start in 2022, with a goal to achieve 100% recycling of targeted plastic waste by 2027.

The roadmap is also identifying fundamental challenges. These range from a lack of legal restrictions on the use of plastic bags, to a lack of regulations to incentivise waste separation and recovery.

To support Thailand in meeting its targets, the World Wildlife Fund (WWF) partnered Metabolic to conduct research into the production, use and disposal of plastics in Thailand. Using a complex systems approach that employed quantitative and qualitative analyses, the study aimed to deepen understanding around the hotspots and opportunities within the Thai plastic waste management system, and to inform and shape further discussions around the circular strategies needed to deliver on future targets.

The research produced an overview of Thailand's plastic waste flow through an approach known as Material Flow Analysis as shown in Figure 2. It sought to facilitate a strategic diagnosis about the entire plastics waste management system in Thailand.



COMPOSITION OF PACKAGING COLLECTED FOR RECYCLING ACROSS DIFFERENT ACTIVITIES

SHARE OF WASTE BEING COLLECTED, MANAGED BY HOUSEHOLD, AND LITTERED IN RELATION TO ACCESS TO COLLECTION SERVICE IN THAILAND (BY PROVINCE)

SHARE OF PLASTIC POLYMERS AND THE END-OF-LIFE FATES IN EACH POLYMER TYPE (KTON)

Mapping Thailand's plastic waste flow.
Image: Metabolic

It would make the jobs of these workers more desirable and go some way in alleviating poverty.

It emerged that bags were the most consumed plastic packaging product in Thailand by weight. The problem is they are light, easily contaminated, of low value and rarely recycled. For this reason, over 60% of bags are improperly disposed of or leaked into the environment. Another point to consider is that waste collection varies widely from city to city. For example, each jurisdiction faces constraints in terms of policymaking and allocation of financial resources.

But there are opportunities for improvement. Take waste collection for example. Thailand relies on both formal waste collectors and informal waste pickers. The latter are the largest stakeholder group in the informal sector and collect the largest amount of recyclable or reusable material. However, they mostly sift out high-value plastic waste that would generate better income, and consequently leave out other plastic items that are considered of low value.

Formally registering these workers could therefore, in a manner of speaking, synergise national and local efforts in tackling plastic waste. For one, these informal workers could become partners with the government and be incentivised to collect waste with lower recycling value. By extension, this would support the public sector in improving the effectiveness of packaging waste collection. Further, it would make the jobs of these workers more desirable and go some way in alleviating poverty. In addition, it would provide waste pickers with the knowledge and equipment to safely perform their work.



Informal waste pickers primarily collect high-value plastic waste that would generate more income. In Kantang Municipality, WWF has engaged waste collectors to also look into picking out non- or low-value plastic waste such as straws, which could then be recycled as pillows, for example, and be distributed to local hospitals.
Image: Kantang Municipality



Waste segregation and collection efforts in Kantang Municipality.
Image: Kantang Municipality

The Outcome

The Metabolic report points to multiple opportunities, as well as challenges, to effect impactful and lasting change in Thailand's plastic waste management.
One model put forward to achieve this is Extended Producer Responsibility (EPR). Aimed at eliminating waste and promoting the continual use of resources, this model is often considered a cornerstone of the transition towards a circular economy.

Benefits of EPR

- **Create awareness:** Foster and strengthen societal awareness of packaging waste and waste management issues.
- **Incentivise eco-design:** Provide economic benefits to design resource-efficient, recyclable products.
- **Scale up recycling:** Increase the effective collection and environmentally sound treatment of packaging waste.
- **Pollution control:** Prevent plastic pollution and limit other negative environmental impacts such as greenhouse gas emissions.
- **Private sector investment, commitment or action:** Among other things, mandatory EPR schemes ensure all obligated companies contribute resources to waste management.

To this end, WWF has shared Metabolic's report with key stakeholders including the Thailand Institute of Packaging and Recycling Management for Sustainable Environment, a non-profit organisation made up of associations and members from packaging and consumer product manufacturers. The grouping did not object to the EPR model but reservations remain due to a lack of study of its economic feasibility. Similarly, at the national and policy level, some resistance remains in getting companies to invest in EPR.

On a local level, however, some projects are already underway. For instance, Kantang Municipality in southern Thailand has engaged local communities to champion eco-tourism by reducing plastic waste flowing into the nearby Andaman Sea and to protect its dugong population. Conversations are also ongoing about efforts to repurpose and reuse plastic packaging that cannot be recycled.

It will truly take a village, and in this case a holistic approach, to tackle the problem of plastic waste. And it is hoped that these and other ground efforts will go some way in pushing conversations between the different stakeholders in Thailand, and ultimately engineer greater awareness and actionable change to support national plastic waste achievements and targets.

CASE STUDY

SINGAPORE | DIGITAL CAPACITY BUILDING

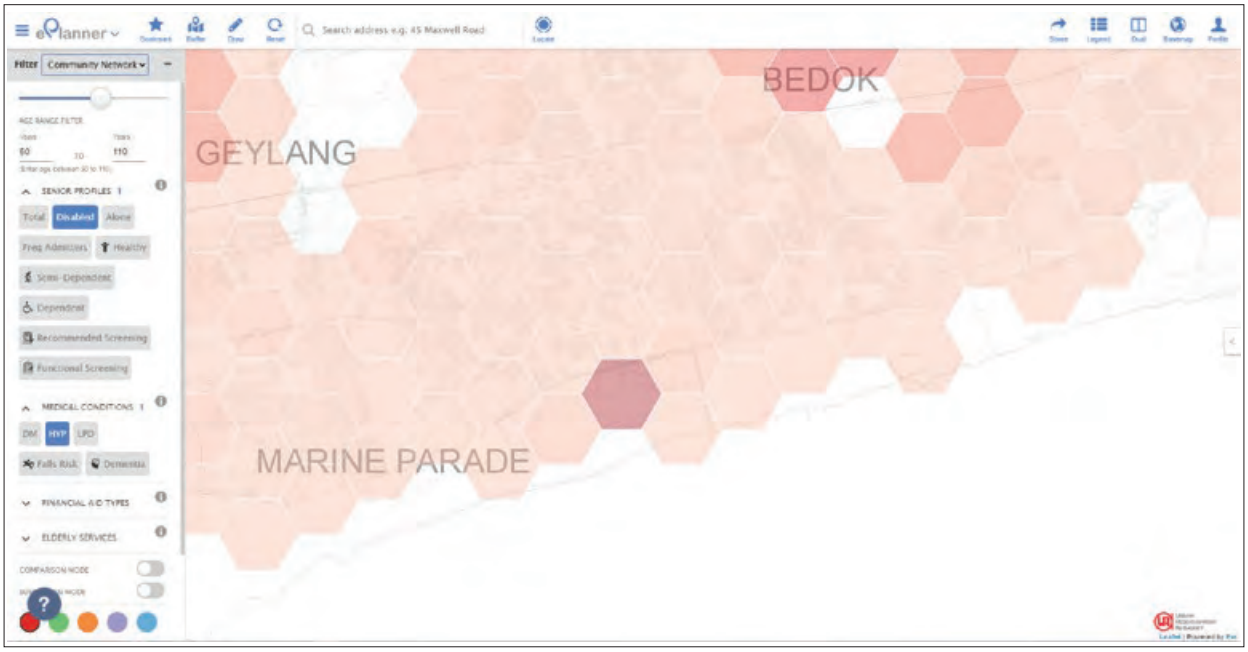
The ePlanner: Integrating Data for Inter-agency Collaboration

Singapore's Urban Redevelopment Authority built a one-stop, multi-platform, geospatial analytics tool in-house that makes accessing data a cinch for urban planners across agencies.





Siti Maziah Masramli is a Senior Content Strategist at Tuber, the editorial consultancy for Urban Solutions.



ePlanner, a geospatial analytics tool.
Image: Urban Redevelopment Authority (URA), Singapore

The Challenge

Having quick and easy access to data is the foundation for using data analytics to support effective digital urban planning.

Since the 1990s, Singapore's Urban Redevelopment Authority (URA) has used geographic information systems (GIS) to manage geospatial data. Planning data such as physical maps were digitised onto an Integrated Planning & Land Use System (iPLAN), a desktop application built in 2007 using ESRI's ArcGIS products.

But the layers of geospatial information took a long time to load and be displayed on iPLAN. This became a major constraint for the wider use of spatial analytics. In 2012, after a review, iPLAN was also due for replacement.

At the 2012 Staff Conference, then URA Chief Executive Officer Ng Lang encouraged URA staff to identify new challenges and think up new ways of doing work to adapt to such challenges.

An idea highlighted was a one-click platform for planners to access the most relevant and up-to-date planning information for any land parcel. These ideas helped shape the vision for the ePlanner, a one-stop geospatial analytics tool.



Workshops to onboard planners to the ePlanner platform.
Image: URA, Singapore

The advent of Google Maps, and the iPhone and iPad, was also changing people's expectations of and interactions with digital maps in everyday life.

The Solution

The URA developed the ePlanner using in-house capabilities. This follows a strategic decision over the years to build and retain strong teams for data analysis, application development and IT infrastructure, having recognised GIS skills as a core need for digital mapping and land-use planning.

To ensure that the ePlanner would be easy to use, then Chief Information Officer Peter Quek challenged the project team to find a solution that could load data in a matter of seconds, using a "mobile-first" approach.

By this time, web mobile map technologies had advanced significantly. The advent of Google Maps, and the iPhone and iPad, was also changing people's expectations of and interactions with digital maps in everyday life.

The first ePlanner prototype was built entirely from scratch by URA staff, who faced a steep learning curve in their first try at building a new analytics portal using GIS.

The team used ESRI's cached map service to quickly display map data as graphics. The key was to make the map data fast and easy to use, with clean summary data and presentation.

The project team also used the Agile software development method. The Minimum Viable Product model allowed the team to shorten ePlanner's initial development

One of the first use cases was to reduce cross-department consultations by allowing planners to easily retrieve all the past planning decisions for a site simply by selecting it on the map platform.

period and bring the pilot ePlanner to planners more quickly.

Planners could then identify the additional data or insights they needed for planning work, interact with and visualise the data in novel ways for planning studies, and work closely with software engineers to rapidly prototype the tools.

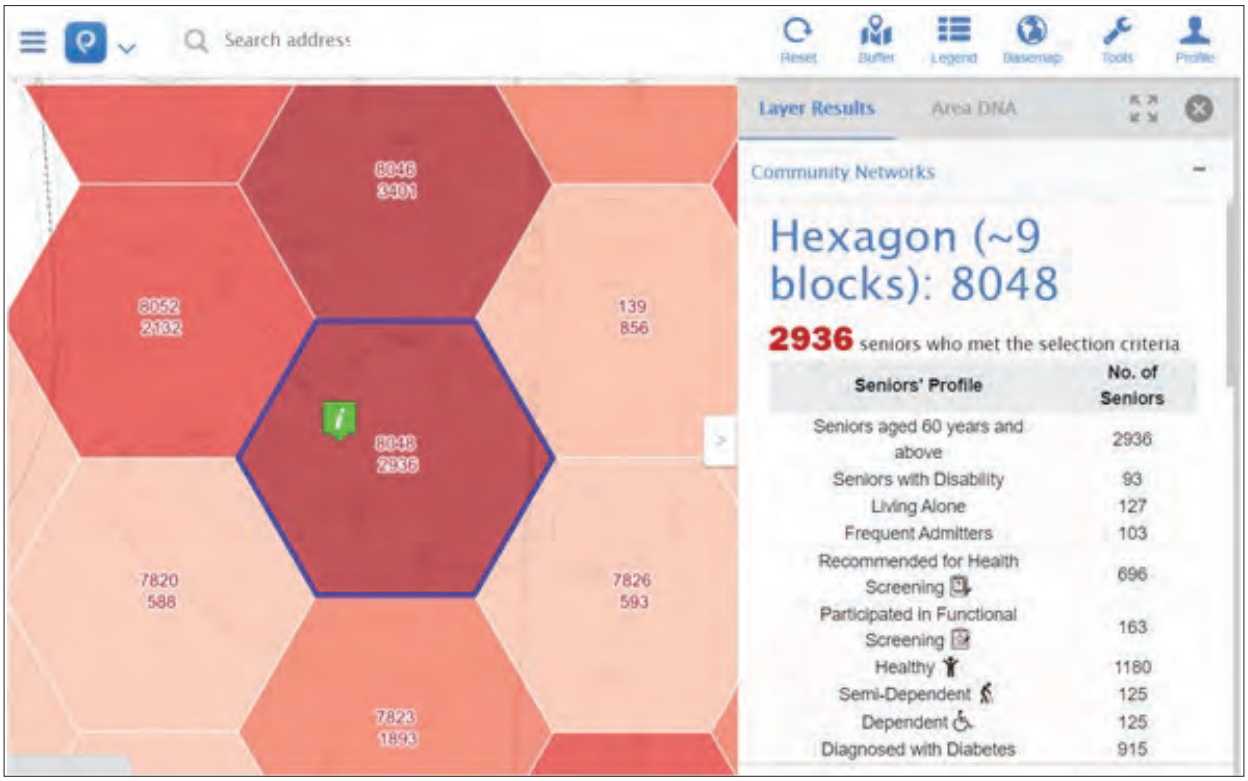
The pilot launch for key users and bi-weekly iterations helped the team to further build their know-how for rolling out new technologies that enable data use for URA's planning processes.

The first version of ePlanner was ready in less than a year in March 2013. It integrated data from various sources (e.g., URA's enterprise systems and public data such as Google Maps) and analysed data to support planning studies.

Users could access the tool via web browsers on laptops and mobile devices like iPads, without the need for specialised software to view the maps and data. The ePlanner could also be easily shared with other agencies. Overall, the application made GIS and data analytics more intuitive and user-friendly to laypersons.

The ePlanner platform could showcase new datasets, demonstrate how complex GIS analysis could be simplified, and be used to present quick planning insights intuitively and interactively.

One of the first use cases was to reduce cross-department consultations by allowing planners to easily retrieve all the past planning decisions for a site simply by selecting it on the map platform.



How the ePlanner is used to identify where there are higher concentrations of seniors living alone.
Image: URA, Singapore

By better identifying "hotspots of needs", such as areas where more seniors live alone, the MOH and AIC can be more targeted in their planning with community healthcare providers to create health and social programmes that meet the seniors' needs.

The Outcome

The ePlanner received good feedback from URA's planners, who recognised that any analysis based on URA's data alone would not bring significant new value to URA's planning.

Rather, the ePlanner could be more effective if it incorporated data from other agencies, such as transport network data, demographic data, and public housing and resident data. The tool could then be used to integrate and analyse relevant data to facilitate the planning and operational needs of agencies.

URA's senior leadership was also impressed by the ePlanner's capabilities and potential value to enhance URA's planning and collaboration with other agencies.

Today, the ePlanner is a multi-platform, geospatial urban planning analytics tool that "makes complex GIS and Big Data analytics very intuitive and user-friendly for all planners", says Anthony Chong, a senior systems analyst at the URA.

It consolidates more than 100 maps and datasets from various sources for easy access by some 50 public agencies. For example, the Ministry of Health (MOH) and Agency for Integrated Care (AIC) work with the URA and use the ePlanner to visualise local data on the senior population to better serve Singapore's ageing population.

By better identifying "hotspots of needs", such as areas where more seniors live alone, the MOH and AIC can be more targeted in their planning with community healthcare providers to create health and social programmes that meet the seniors' needs.

Other lessons from this process of creating the ePlanner include the importance of dedicating resources to having comprehensive and up-to-date data, the benefits of empowering staff to contribute ideas, the need to raise awareness of new methods and technologies, and how to convince other agencies to adopt this new way of collaborative working.

The ePlanner is just one of several digital initiatives within the URA's Digitalisation 2.0 Roadmap. With common data sharing and visualisation platforms across agencies, the URA aims to have a more data-informed work process and better planning outcomes with integrated planning across the whole of government.

URA's Director of Master Planning and Urbanism Wang Wei says: "I can't remember life before these tools. It makes it easier to find the necessary data as well as undertake quick analysis to facilitate our evaluation purposes."

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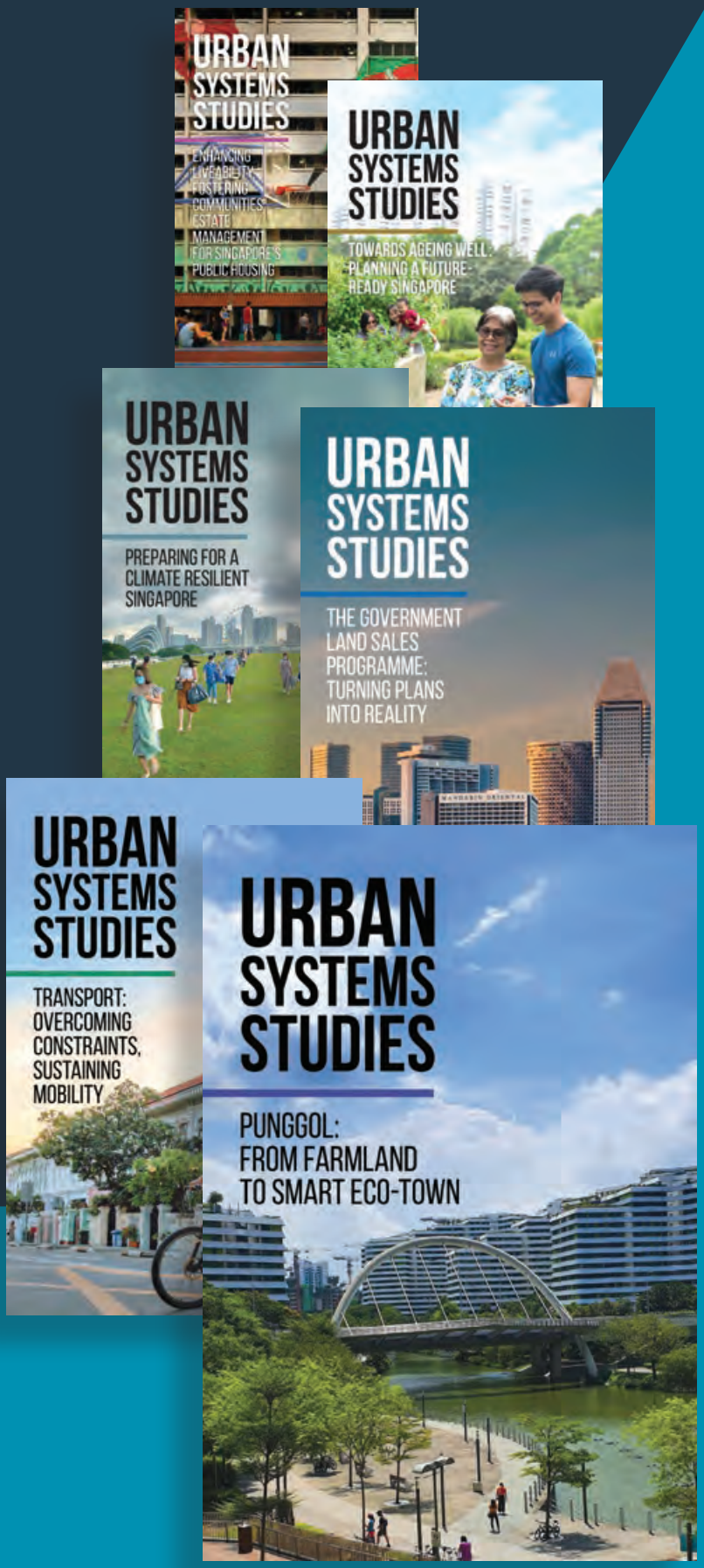
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