Chapter 1
Introduction to 'Planning Support Science for Smarter Urban Futures'

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Abstract This introductory chapter establishes the context for subsequent contributions by outlining some of the major physical and social challenges that confront planners and policy-makers in different parts of the world. It then explains how the development of planning support systems has evolved into a much broader field of Planning Support Science which intersects with the emergence of data science, big data, data analytics and new urban science, thereby creating new opportunities for innovative solutions to support progress towards the development of smarter and more resilient urban futures. The structure of the book is clarified and short summary reviews of each chapter provide a composite portrait of the contents as a whole.

Keywords Planning support systems · Smart cities · Urban futures

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1 Introduction

We are living in an increasingly urbanized world; a tipping point was crossed in 2008 when more than 50% of the global population was reported to be living in urban areas (United Nations 2014). Furthermore, this urbanization process is expected to result in more than 60% of the world's forecast population of 8.5 billion to be living in urban areas by 2030 (United Nations 2014). The number of cities with over a million inhabitants is due to increase nearly 30% from 512 in 2016 to 662 in 2030 (United Nations 2016) and the number of 'megacities', those with more than 10 million residents, is forecast to rise to 41 in 2030 from 31 in 2016. In 15 years' time, the United Nations (2016) predict that 27% of the world's population will be living in cities with at least 1 million people. Whilst these statistics are themselves striking, the implications or consequences of these demographic changes are far-reaching and present major challenges. Forecasts suggest that 2 billion people living in urban areas in 2030 will be living in slum areas (UN Habitat 2003), for example. The United Nations (2016) estimate that 56% of the 1,692 cities with populations of at least 300,000 in 2014 were at risk to at least one of the six types of natural disaster (cyclones, floods, droughts, earthquakes, landslides and volcano eruptions). In fact, "*a majority of city dwellers live in cities that face high risk of disaster-related mortality or economic losses*" (United Nations 2016, p. 9).

There are many other challenges facing the world's cities which planners and policy-makers need to give their urgent attention to, such as increasing traffic congestion, which in Australia alone is expected to cost $30 billion of Gross Domestic Product (GDP) by 2030 (BITRE 2015). The increase in the number of people driving cars is causing other related problems such as the decline in air quality which is now the world's fourth leading fatal risk factor. Air quality was responsible for 5.5 million premature deaths worldwide in 2013, estimated to cost the global economy $225 billion in lost income (World Bank 2016). In fact, air pollution costs the world's economy $5.11 trillion in welfare costs (World Bank 2016). Moreover, the consequences of air pollution are not just identified as financial; they also cause major changes in people's patterns of behaviour. In December 2016, for example, it was reported in the press that tens of thousands of 'smog refugees' were leaving the cities and industrial areas of northern China to escape the 'airpocalypse' caused by the blanket of toxic fumes (The Guardian Website 2016).

We are also facing major health crises with respect to obesity and associated diseases such as type II diabetes, on the one hand, and famine and malnourishment on the other. There are 422 million people in the world with type II diabetes and, according to the World Health Organisation (WHO), numbers have quadrupled since 1980 (WHO—http://www.who.int/diabetes/en/). The United Nations Food and Agriculture Organisation (FAO) estimate that around 795 million people in the world are undernourished, most of whom are living in developing countries (FAO 2015). The world is in an age of anthropogenically-induced climate change which is resulting in increased temperatures and natural events such heatwaves, floods and sea level rises. All of these environmental factors have serious implications for cities and all who live in them. In addition, shifts are taking place in the geodemographic and geopolitical landscape with the aging society, the increasing mass migrations, and the rise of a strong anti-globalisation sentiment in the powerhouses of the Western world, as illustrated through Brexit and the emergence of Trump as the 45th President of the United States, all of which encourage uncertainty and make effective planning and decision-making that much more challenging.

It is with this shockingly sombre backdrop that we introduce this volume on ‘Planning Support Science for Smarter Urban Futures.’ Never has there been a more important time for communities, planners and policy-makers to work together more closely and collectively to address the pressing issues facing the cities in which we choose to live in increasing numbers. Yet several glimmers of hope have emerged in this current age of digitization, big data and smart cities, indicating that Information Technology and Communication (ICT) and data driven approaches (data science and informatics) may be brought to bear to support planners and policy-makers in dealing with some of the grand challenges facing our planet.

Planning Support Systems (PSS) can be defined simply as computer based-tools which can assist planners to more effectively undertake their day to day jobs. In the broadest sense, PSS are computer based tools which add value to the planner’s work processes, including spreadsheets and websites to Geographical Information Systems (GIS) and visualization and beyond (Couclelis 2005). Another definition (Geertman 2006) considers PSS as geo-information technology-based instruments that are dedicated to supporting those involved in planning in the performance of their specific planning tasks. Whilst there are numerous other definitions of PSS available in the literature (see for example, Batty 1995; Klosterman 1997), what is common to all is they are computer-based tools to support planners in undertaking planning-specific activities.

PSS came into being in the late 1980s as described by Harris and Batty (1993). They arose through a convergence of efforts being undertaken in the areas of GIS, large-scale urban models and Decision Support Systems (DSS). PSS were in some way a response to the backlash from planners and policy-makers to top-down, black-box models which were being run to optimise city development. This is resoundingly articulated in Lee’s famous ‘requiem for large-scale urban models’ (Lee 1973). PSS are those tools that *support* planning activities, not *replace* planners in undertaking strategic planning and other activities. This is an important distinction to the black-box land-use and transport models in the 1970s, some of which are still used today to optimise city outcomes through a series of equations. In the 1990s, a number of PSS were developed which enabled planners to interact and use these tools themselves through Graphical User Interfaces (GUIs). Planners could change parameters through the use of slider bars and other means and explore the likely implications of these changes through map visualisation, bar charts, *et cetera*. Thus planners could begin to explore *what if?* urban scenarios; for example, *what* would happen *if* the population increased for a defined urban geography by 3% per annum instead of 1.5%?

Early PSS included systems such as CommunityViz (Kwartler and Bernard 2001), INDEX (Allen 2001), What if? (Klosterman 1999), and UrbanSim (Waddell 2002). Several of these PSS, and others, have stood the test of time and in their various incarnations are still used in planning practice 20 years on, such as the open source online version of What if? (Pettit et al. 2013, 2015a, b) and the cloud-based UrbanSim due for release in 2017. In recent times, there has also been a focus on improving the user experience for planners interacting with PSS through studies and experiments undertaking more engaging interfaces such as maptables (Arciniegas et al. 2013) and the beginning of empirically-driven PSS user studies (Russo et al. 2015).

However, as Vonk et al. (2005) and others have noted, the implementation of PSS has not been without its challenges with the adoption in practice not as widespread as the PSS developer community might have hoped for (Geertman and Stillwell 2003). Yet with the emergence of the smart city, digitisation, big data and the opening of government data repositories, there are new opportunities for PSS to embrace this shift towards the digital paradigm and increase their visibility and uptake as geo-information toolkits which can support a number of urban planning tasks. It is due to this much widened perspective on PSS that we prefer to speak of an upcoming scientific field of ‘Planning Support Science’ with an emphasis on the goal of support instead of focusing just on the system-side of PSS (Geertman 2013).

Increasingly, PSS are embedded in digital data infrastructures which form an integrated whole, such as in the case of the Australian Urban Research Infrastructure Network (AURIN) online workbench which provides access to over 2,000 datasets, 100 spatial statistical tools and a constellation of PSS (Pettit et al. 2015a, b, 2017). Furthermore, for their acceptance in planning practice, PSS request an attuning to the specifics of planning practice, to the intended application, and to the context of that application. This attuning, its needs and its associated methodology have become a field of research in its own right (Geertman 2006, 2013). In addition, the upcoming concept of smart city has blurred the distinctions between systems, tools, instruments, apps, social media, big data, *et cetera*, that all by itself can fulfil an ICT-based supporting role in planning practice. It is for all these reasons that we prefer now to use the term Planning Support Science (Geertman 2013). In recent times we have also seen the rise of a new science of cities (Batty 2013) and big data and data science as applied in the context of shaping cities (Thakuriah et al. 2017). The intersection of Planning Support Science, city or urban science and data science is offering exciting new possibilities in data driven approaches to city planning.

It is in this context that this book builds upon research presented in the previous volumes of this series of PSS books (Geertman and Stillwell 2003, 2009; Geertman et al. 2013, 2015). In supplement to the most recent themes of ‘PSS for Sustainable Urban Development’ (2013) and ‘PSS and Smart Cities’ (2015), in this volume we introduce the term ‘Smarter Urban Futures’. In doing that, we emphasize the future-oriented nature of planning and our focus therein is predominantly dedicated to the urban environment. In that, in accordance with the theme of the CUPUM 2017 conference, we also emphasize the orientation towards the idea of resilient and smart urban futures. We are of the opinion that in a time of increasing human and natural disasters and global instability, the focus on smartness and resilience is a logical choice and a serious matter. For instance, just recently we have seen the emergence of resilience with, most notably, the establishment of the Rockefeller Foundation’s 100 Resilient Cities Programme. The Rockefeller Foundation provides a definition of resilience as “*the capacity of individuals, communities and systems to survive, adapt and grow in the face of stress and shock, and to even transform when conditions require it*” (Rockefeller Foundation 2015, https://www.rockefellerfoundation.org/our-work/topics/resilience/).

Sanderson (2016) views resilience as an aspirational paradigm, yet it has elements of newness which could provide opportunities not previously possible in engaging planners, and decision-making in response to stress from the shocks facing our cities and all those who live in them. The term ‘city resilience’ is relatively new too and has been defined by da Silva (2016, p. 5) as “*the capacity of cities to function, so that the people living and working in cities—particularly the poor and vulnerable—survive and thrive no matter what stresses or shocks they encounter*”. In addressing city resilience, there is a need to support planners and policy-makers with data analytics, models, simulations, dashboards, participatory frameworks and interactive tools and visualisations; so in short, a much smarter environment than most of the present. As such, PSS can provide a modest contribution to the armoury of tools and techniques required to support planners in both envisioning and realising more resilient and smarter urban futures.

The chapters that follow in the remainder of the book therefore collectively provide a state-of-the-art perspective on the general field. As editors, we have decided to separate the contents into two sections: those that are predominantly focused on explaining PSS and their applications, and those that have a wider remit or which consider smarter urban futures more explicitly. In each section, we offer a short synopsis of each chapter as a means of providing a more composite picture and a rationale for the order in which chapters are presented.

2 Planning Support Science

Cities are complex, dynamic systems whose regulation or development through planning requires increasingly sophisticated methods to understand, model, predict and formulate strategies and plans for the future. In all steps or stages of the planning process, the evidence base is derived from the existence of information about the past and present, together with details about scenarios for the future; in all cases, effective decision-making is enhanced by information and data from a diversity of sources. The volume and diversity of data types is expanding rapidly, not least as new big data sets come online, sometimes via social media. Consequently, the field of Planning Support Science is characterised by the continuous development of frameworks to incorporate new data, new types of data and new ways of linking data from different sources together for the benefit of analysts, planners and decision-makers. It is therefore unsurprising that the chapters in the first section of the book tend to reflect work ongoing on PSS in different countries around the world that is based on exploiting the data in different ways, developing new indices for measuring and monitoring change and using new methods for visualising and analysing new data sets. The first five chapters all have a primary focus on data, metrics and indicators.

The first chapter of this section (Chap. 2) written by *Claire Daniel* exemplifies the construction of a web-based mapping system as the prototype of a PSS for mapping the effects of urban planning policies. In this work, data on development permits, land uses, infrastructure and services are assembled for four cities in three different countries as the pre-requisites for automated mapping and for allowing comparisons to be made between the structure of the planning systems, the data available, the metrics that are appropriate, and the visualisation methods.

A major factor in determining whether a city or a community can survive, adapt, and develop in the face of stresses and shocks is the configuration of its component structures; its roads, buildings, vegetation, waterways, open spaces, for example. PSS have been developed in the past to measure conditions, design future scenarios, identify performance indicators and evaluate scenarios according to the extent to which they achieve the goals that have been established. One example of such a system is INDEX (Allen 2008), a tool developed by Criterion Planners of Portland Oregon which supports scenario planning at different spatial scales by measuring the resilience of scenarios. INDEX has an in-built set of indicators of land-use, urban design, transportation and the environment but users can implement indicators designed for local issues. Chapter 3, by *Fernando Lima*, *Nuno Montenegro*, *Rodrigo Paraizo* and *José Kós* explains and evaluates the implementation of a not too dissimilar system called Urbanmetrics, an indicator-based methodology which serves to measure how a neighbourhood is configured based on Transit Oriented Development (TOD) principles. The system computes indicators that consider physical proximity, topology and walkability as well as the diversity of an area and the chapter reports the results for a case study of a medium-sized city in Brasil using a multi-objective optimisation plug-in.

In Chap. 4, *Alireza Karduni*, *Isaac Cho*, *Ginette Wessel*, *Wewen Dou*, *William Ribarsky* and *Eric Sauda* provide an introduction to the possibilities of using advanced programming techniques to analyse the possibilities of enabling social network data, including tweets, to feed PSS. The prototype system, known as the Urban Activity Explorer, adopts interactive Visual Analytic Systems (VAS) to allow the exploration of very large datasets (e.g., 1 million tweets over two months) for Los Angeles, to identify hotspots of activity and their development over time, demonstrating the valuable role of mobile social media as a source of information about activities across the city.

The following Chap. 5 by *Toshihiro Osaragi* and *Noriaki Hirokawa* has the specific aim of mitigating the effects of a large earthquake, by identifying those urban fires that are most likely to spread widely and therefore by concentrating firefighting resources on these locations. The chapter introduces two new indicators; firstly, the number of buildings that are expected to be destroyed by fire spreading from one specific building, the so-called fire-spread potential index; and secondly, the burn-down potential index, the probability that a building will burn down given the outbreak of fire within the building itself but also from fire spreading from surrounding buildings. The chapter reports on agent-based simulations of the spread of fires throughout the Tokyo Metropolitan Area and the resulting surfaces for the two indexes are plotted and analysed.

One major issue for planners in both the developed and the developing world is to find suitable land for human settlement and suitable sites for new housing. Nowhere is this more apparent than in South Africa, where the Government produced a new human settlements plan in 2004 (Breaking New Ground) which aimed to eradicate informal settlements and to reinforce the Department of Housing's vision of encouraging the creation of a non-racial, integrated society through the development of sustainable human settlements and quality housing. Chapter 6 explores the spatial analysis that was undertaken to determine land that was available for an additional 100,000 housing units over the next five years. The authors, *Baleseng T. Mokoena*, *Walter Musakwa* and *Thembani Moyo* explain the methodology used to construct a new index called the Well-Located Land Index (WLLI) based on a GIS and making use of Multi-Criteria Decision Making (MCDM). The index is defined as a function of various criteria that are used to identify well-located land. These criteria were identified through a workshop involving professional and academic stakeholders and weighted using the Analytical Hierarchy Process (AHP). Different classes of suitability of land for housing are mapped using ArcGIS for the Ekurhuleni Metropolitan Municipality, not far from Johannesburg. The authors demonstrate the feasibility and appropriateness of the index to identify new housing opportunities efficiently and appropriately, but the caveat is that within the community, and amongst planners in practice, there is a marked reluctance to embrace technologies in the planning process. It is commented that innovative policies that could fulfil the goal of smarter, more resilient cities are not the problem; rather there is a lack of implementation and innovation that constrains progress.

Chapter 7 continues the theme of combining data from different sources by looking at how urban areas can be designed to be more resilient in the face of serious effects of climate change on urban forests. In a world with ever-increasing volumes of data are held in increasingly large repositories, there is a major challenge for planners to develop systems that exploit the opportunities available for more effective urban planning and design. In many cases this involves bringing together different types of data and information sets in a dynamic manner from a range of disparate sources. It has now become commonplace for local authorities in some countries to develop web-based interfaces that allow users to access information that they consider useful for understanding the spatial characteristics and dynamics of their localities (e.g., Marsden 2015). The chapter by *Nano Langenheim*, *Marcus White*, *Jack Barton and Serryn Eagleson* is closely tied to the theme of urban resilience in that the authors focus on some of the challenges confronting planners in cities in Australia caused by changing environmental conditions and explain how PSS can be used to assist decision makers utilise the available data to assemble evidence that can thereafter be used to formulate policies that encourage buy-in from local stakeholders. Two examples are used, the first exploring scenarios for urban forest design in the Melbourne suburb of Elwood, a district prone to tidal inundation from sea level rise. The second example describes the potential for combining data on street networks, traffic flows and topography and uses a pedestrian catchment modelling tool to improve accessibility to a primary school in an inner suburb of Melbourne, thereby helping the local authority formulate its infrastructure design in a way that is beneficial for school children and their parents.

In Chap. 8 by *Jennifer Minner*, the use of geodesign, 3D visualisation and scenario planning methods and tools is examined in the management, remediation, rehabilitation and long-term planning of post mega-event locations for two test bed sites, Hemisfair Park in San Antonio, Texas and Flushing Meadows in New York City. Both sites hosted World Fairs in the past, celebratory mega-events that provided an opportunity to showcase activities, products, technological prowess and achievements. The paradox of these mega sites is that once the short-lived mega-event has passed, they lapse into a pattern of underutilisation and decay that unfortunately perpetuates the original problematic nature of such sites. This chapter highlights that the post-planning of these sites provides the opportunity for better planning and urban management because the large scale of such sites suits the use of sophisticated tools which is critically important to achieving sustainable and resilient urban areas. A design workshop held at Cornell University allowed students the opportunity to use the two case study locations to undertake planning and design studies using PSS tools such as City Engine, Envision Tomorrow, ArcGIS, Photoshop, Google Earth, Sketch-up, 3D warehouse and the GIS portals of local and federal government agencies. The geodesign PSS is examined, from which it is concluded that whilst geodesign planning tools have value, there is still considerable potential for GIS elements to be better integrated with architectural visualization software. Geodesign tools omit Building Information Management (BIM) tools, and this does limit development feasibility and resilience planning. It seems that whilst great strides have already been made in the development of geodesign PSS, there is still significant scope for improvement, particularly with regard to integration of various digital platforms and ease of use.

The following two chapters deal with an increasingly popular field of PSS development, that of urban walkability, and follow on logically from the second example used in Chap. 7. The first, Chap. 9, written by *Claire Boulange*, *Chris Pettit* and *Billie Giles-Corti*, reports on the development of a PSS that aims to improve the relationship between the build environment, walkability and health, as well as fostering collaboration between researchers working in an academic environment and urban planners. The so-called Walkability PSS has been built to promote healthy built environments and therefore create more resilient urban areas. It allows users to sketch precinct plans on a digital map using a tabletop (MapTable) interface; it then estimates that probability that an adult walks to a destination using information about the roads, the land-use types and the public transport modes that are available. The estimated probabilities are updated in real time and displayed on an interactive chart. The PSS is built on the CommunityViz 5.0 software and aims to assist planners in developing healthier communities by allowing them to test alternative planning scenarios and what the impacts will be on people's walking habits. The main focus of this chapter is not on explaining the PSS itself but on its evaluation; to this end, the chapter reports the responses of seven participants at a two-hour workshop to questions about the system's usability, suitability and potential application areas. In all cases, the study finds the Walkability PSS to be well received and relevant for understanding the impacts of alternative policies.

The second walkability Chap. 10 is by *Kayoko Yamamoto* and *Shun Fujita* and outlines the structure and function of a system that provides guidance for tourists navigating their way around the city of Yokohama in Japan, assisted by the provision of real-time information derived from social media. Tourists who are unfamiliar with the city can change their routes dynamically and visit the sights of the city more efficiently, using augmented reality technology to explore the real space that surrounds them. Navigation outdoors is facilitated by users wearing smart glasses or carrying mobile information terminals. They can also move around the city more safely because the system is designed for use in times of disaster as well as times of normality. The chapter reports how the system was evaluated by a sample of users under both scenarios.

In Chap. 11, *Yiqun Chen*, *Abbas Rajabifard* and *Jennifer Day* outline a new Application Programming Interface (API) for enabling the calculation of isochrones —lines of equal travel time—around selected nodes. Typically these are based on transportation routes such as public transport infrastructure, roads, footpaths, *et cetera*, rather than simply circular buffers around a point, and specialist software is available to construct isochrones (e.g., Microsoft's MapPoint, ESRI's Network Analyst). The new free-of-charge web service for constructing isochrones created by the authors is designed to encourage use by planners without the need to obtain proprietary software. The chapter outlines how their isochrone calculation is based on a breadth-first-search algorithm for searching graph data structures, presents the pseudo-code of their algorithm, and demonstrates the approach using road network data extracted from OpenStreetMap which has to be cleaned to ensure all isolated road links are eliminated. The web service API is exemplified using a number of isochrone scenario requests using seed points in Melbourne, i.e. compute isochrones: for N points with the same distance; for N points with N distances; for N points with different distances; and for N points showing points, links and polygons. The chapter finishes by reporting the performance of the API in terms of processing a large number of calculation requests with three isochrones search distances (500, 1000 and 1500 m) using a test area in Melbourne comprised of geographical units with populations of over 200 persons.

The penultimate chapter of this section of the book focuses on the use of microsimulation modelling at the household level. Chapter 12 is authored by *Nao Sugiki*, *Kazuaki Miyamoto*, *Akinari Kashimura* and *Noriko Otani*, and uses an agent-based household microsimulation approach to study the demographic changes that may arise over the next few decades within two different communities in the suburbs of Tokyo. The focus of the chapter is on understanding the impacts of an aging population on the composition of the suburban communities and on their quality of life. The approach that the authors have taken to building a synthetic population is original in that it relies only on Monte Carlo sampling instead of a combination of Iterative Proportional Fitting (IPF) and Monte Carlo sampling.

The final chapter in this section of the book is one which considers smart technologies for collecting social data for use in PSS and therefore provides a nice bridge to the next section. Chapter 13 is authored by *Wencheng Yu*, *Qizhi Mao*, *Song Yang*, *Songmao Zhang* and *Yilong Rong* and focuses on social sensing, the collection of observations about the physical environment from human beings or devices acting on their behalf. The authors suggest that most social sensing research and applications in urban planning hitherto have been on the structure of urban space, population flows, transport networks and citizen's activities rather than on semantic cognition and social relations. Their approach is to use methods of data cleaning, word segmentation, word clouds, sentiment analysis and topic analysis to gather citizens' thoughts, opinions and ideas on issues that will support planners' decision-making and they use the renovation of an old district of south west Beijing as a case study to test their framework. Whilst it is undoubtedly the case that there is value in the intelligence that is gathered from local people by sensing and analysed using the methods exemplified in the chapter, the way in which this information feeds into the planning process that brings about renovation and the influence that it has on decision-making remains unclear.

3 Smarter Urban Futures

During the last couple of years, the concept of 'smart cities' has been taken up by many city leaders, planners, IT companies and scholars worldwide. It appears that the field of Planning Support Science, as dealt with in the previous section, is becoming more and more part of the instrumental toolbox of smart cities. As a consequence, the boundaries between these two fields of research and practice are getting increasingly blurred. Topics like open and/or big data, city indicators, real-time data visualizations and data analytics increasingly play an important role in both fields. This is something that can be observed all around the world and at very different levels of administration in different countries. And happily, this is not just an academic debate; the fields of PSS and smart cities increasingly trigger close collaborations between governmental organizations, private firms and non-governmental organizations including academia, as is shown by many of the contributions in this book.

The first chapter of this section (Chap. 14) deals specifically with the topic of the increasing integration of PSS and smart cities. Therein, the authors, *Vinutha Magal Shreenath* and *Sebastiaan Meijer*, ascertain that big data are currently used mainly for operational understanding and as improved data sources for existing design methods. Contrarily, in their opinion, big data are hardly ever applied for long-term planning and design purposes. To overcome this deficiency, they present an application of big data for finding suitable locations for deploying charging infrastructure for vehicles, such as the Electrical Road System (ERS). With the help of these big data, potential locations are identified for placing static charging installations and relevant road segments are selected to locate dynamic charging installations. The authors conclude that the combination of big data with expert knowledge can be very valuable for the design of future urban transport systems.

In Chap. 15, *Li Meng*, *Andrew Allan* and *Sekhar Somenahalli* examine past PSS and note how they have shaped the modelling of land use and transport planning at the metropolitan scale for two Australian cities, Adelaide and Perth. The authors examine proposed new metropolitan scale models for each of these cities that, whilst complex, incorporate a more integrated and sophisticated approach that is responsive to future challenges and community preferences by exploiting the latest innovations in PSS in terms of data and new integrated modelling platforms. These two cities have similar morphologies in that their growth has been biased to their north-south axes because of geographical constraints (ocean on their western flanks and higher ground on their eastern flanks). During the mid-20th century, both of these cities were of a similar size and population, but since Western Australia has reaped the benefits of a sustained mining boom during the past half century, metropolitan Perth's population of 2 million has long eclipsed that of metropolitan Adelaide, which is now home to 1.3 million people. In the case of both of these cities, the authors note that the PSS that have been used to support the planning and modelling of Adelaide and Perth are characterized by traditional approaches that have failed to take advantage of the latest advances. In the case of Adelaide, the key restrictions appear to be that past approaches have worked and are still working, so why update data sets unnecessarily or increase modelling complexity? In the case of Perth, growth has been so rapid and intense that planners have struggled to keep pace with planning to anticipate the changes even with using the latest data and modelling technologies. However, the authors note that with competing policy priorities that include developing future resilience to looming environmental challenges, against a backdrop of a restructuring economy and the social stresses that go with that, and a fragmented ideologically rigid polity, more than ever before we require smart city policies that recognize and embrace these policy complexities. Revised metropolitan models are put forward for both Perth (PLATINUM) and Adelaide (AITLUM) that embrace the state-of-the-art in PSS, and are sufficiently sensitive and responsive to manage an era of rapid change and uncertainty.

In Chap. 16 by *Tayo Fabusuyi* and *Robert C. Hampshire*, innovative use is made of the United States Census of Public Use Microdata Sample (PUMS) to examine commuting patterns in the United States, and more specifically in the Greater Pittsburgh area, the region used as a test bed. The authors have developed a discrete choice model with commuter profiles to explore differences in commuting patterns according to place of abode and socio-economic background. The authors have a radical suggestion that is certain to generate heated debate amongst transport policy-makers and planners in doing away with rigid overarching plans driven by a regional transportation strategy, and instead having an adaptable 'on-the-fly' demand-driven policy regime. Parking is singled out as one policy area where a demand-driven approach could work through the use of smart phone apps and Vehicle Messaging Services (VMS). Innovative public-private partnerships with peer-to-peer mobility through apps such as UBER and driverless vehicle technology, currently being trialled in Pittsburgh, raise the prospect of a dynamic transportation system that will necessitate policy responses to be made in real-time. This chapter points to uncertain times ahead for regional strategic transport planning in US cities as they make a fascinating transition towards a demand-driven policy environment, where user choices of digital technologies will determine transport infrastructure investments in future.

In Chap. 17, Australian researchers *Nicholas Holyoak*, *Michael Taylor*, *Michalis Hadjikakou* and *Steven Percy* develop an integrated demand and carbon forecasting approach for residential precincts. The research project is part of an initiative of the Australian Government's Commonwealth Research Centre for Low Carbon Living which has, as part of its remit, the task of reducing future carbon emissions from Australian urban areas. Up until recently, government initiatives in Australia (such as Basix, Nathers and FirstRate5) and internationally (EnergySmart Homescale in the US, Breeam in the UK and LEED in Canada) have aimed at reducing carbon emissions by focusing efforts on modelling individual dwellings and requiring minimum baseline environmental performance standards at the planning approval stage and prior to construction occurring. Such approaches have been limited in modelling actual expected environmental performance in practice because they fail to take into account what happens at the level of the precinct, suburb and city, due to the fact that they assume a worst case operational scenario (i.e. where every urban resident consumes water, energy and resources at an 'average' rate), and they have given minimal consideration to location or particular socio-economic circumstances and behaviors of urban residents. By shifting the demand forecasting approach to the precinct level, this example of a PSS uses the latest in modelling technology, GIS and behavioral science to use a common set of inputs covering energy, transport, waste, land use characteristics and resident household types, that interact with various 'low carbon living' technologies (such as electric vehicle usage, recycling, solar photovoltaic panels, battery storage and rainwater tank use), to create various scenarios of low carbon living of households and other land uses aggregated at the urban precinct level. The researchers applied this precinct carbon emissions forecasting tool to the redeveloped master-planned Adelaide suburb of Tonsley to predict equivalent carbon dioxide emissions for the year 2035 that would be likely with the take-up of various low carbon emissions technologies in its planned urban development options. The potential of such a model to accurately forecast carbon emissions performance of large urban areas is clearly demonstrated in this chapter and it highlights the importance of transitioning from environmental performance rating schemes that focus on buildings to schemes that have the capacity to model the environmental performance of large complex urban areas.

Following on from this theme, the next contribution shows how open data about human opinions and perceptions can contribute to the proper design of public space. The author of Chap. 18, *Eleanna Panagoulia*, shows how data related to human perceptions can add value to more conventional datasets (such as income, crime, educational level, *et cetera*) for the evaluation of the urban environment. This is exemplified via a case study that focuses on mapping the gentrification rate in the San Francisco Bay Area. This phenomenon occurs rapidly in this area and as such it can be considered a challenge to visualize due to its dynamic and complex character. In response to this problem, the author proposes an accumulative analysis that consists of three methodologies that operate at different regional and local scales. The results of the three methodologies are assessed and the evaluation suggests that close engagement with technology has lead the researchers to explore a multitude of research methods, each of which has contributed to more accurate statements about the urban space.

Open data increasingly play a decisive role in the concept of smart cities, although until now mostly in the management of cities and less in the planning and decision-making activities. The next chapter exemplifies the role of the concept of smart cities in planning and decision-making. In Chap. 19, *Chris Pettit*, *Scott N. Lieske* and *Murad Jamal* present a review of the international efforts in the creation of so-called 'city dashboards'. They have looked at the role of city dashboards in communicating city data, and how they are used more broadly as a type of PSS to aid in the planning, management and monitoring of urban systems. Based on their review, they introduce the City of Sydney Dashboard, known as CityDash, and discuss its purpose, architecture and future development. They also provide a set of recommendations on how dashboards can play an important role in assisting in city planning and citizen engagement. These recommendations range from the need to consolidate information on a single web page, to providing live data feeds relevant to planners/decision-makers as well as to citizens' daily lives, and the inclusion of site analytics as a way of evaluating user interactions and preferences.

In the following Chap. 20 of this section on smarter urban futures, the topic of so-called 'city metrics' is considered. Cities use a variety of metrics to evaluate and compare their performance, for instance in their quality of life or their sustainability. Comparative analysis of city performance has been enabled by the definition and adoption of city indicators, such as ISO37120. However, for a fruitful comparison of indicators the consistency in the underlying data is of utmost importance. City indicator consistency analysis enables the possibility of consistent measurement and comparison of city performance. In their contribution, *Yetian Wang* and *Mark S. Fox* present three types of consistency analysis for automating the detection of inconsistencies in open city data: definitional consistency analysis that evaluates whether data used to derive a city indicator are consistent with the indicator's definition; transversal consistency analysis that evaluates if city indicators published by two different cities are consistent with each other; and longitudinal consistency analysis that evaluates whether or not an indicator published by a city is consistent over different time intervals. With the help of these three types of consistency analysis, a comparative analysis of city performance will yield comparable outcomes.

Ming-Chun Lee investigates in Chap. 21 scenario-based planning practices in the United States that connect regional planning frameworks to local scenario planning (characterized as 'finger printing' processes). The system at the core of scenario-based planning approaches is GIS, which not only allows a static spatial representation of past and current land uses but, when combined with 'what if' scenario software, the different policies and their societal and environmental changes can be dynamically modelled to determine likely effects and development outcomes over varying timeframes. At the local level of scenario testing, Lee stresses the importance of 2D and 3D visualization using the ESRI program CityEngine as a planning tool. Case studies are used at both the regional and local scales to illustrate how regional planning frameworks set the scene for local planning responses. The technology of the planning tool is stressed as important to the planning and design of smarter cities, by incorporating better understanding and improved informed decisions. Moreover, Lee explains that it promotes engagement with the community, results in political coalitions and builds organizational capacity. Whilst planning across scales may imply a top-down planning approach where regional priorities lock local planning into a straight-jacket, Lee argues that a holistic approach and local 'finger printing' can facilitate unique local needs whilst simultaneously maintaining the integrity of an essential regional perspective.

Chapter 22, by *Simone Z. Leao*, *Nam Huynh*, *Alison Taylor*, *Chris Pettit* and *Pascal Perez*, explores an innovative method that integrates a mapping scenario-based approach with both a synthetic population model and a synthetic transport model developed out of a travel diary to help investigate an urban growth scenario for Sydney, Australia's largest city, with modelling outputs that include estimating future housing demands and centres of activity associated with daily trips or hotspots. The innovative and novel aspect of this modelling approach is that whilst the modelling itself is hypothetical (or synthetic as the authors prefer to call it), it is based on real world big data inputs, such as Australia's national population and housing census and an actual travel diary survey. Interestingly, it is used to create actual housing and travel demand projections for a planned urban growth corridor in Sydney's inner southern suburbs where the population is expected to double over the next 15 years. To increase the reach of the work to a general audience, the researchers developed a map-based visualization called Synt-Viz that used freely available cloud computing tools such as the Carto online mapping platform and the ESRI Story Map software. Urban planners often advocate smart growth as essential to better urban planning and management, and with the work described in this chapter, the authors have a planning analytical approach and planning support tools that go a considerable distance towards achieving this goal.

Chapter 23 by *Rida Qadri* examines the vexed question of planning and regulating street vending in New York City. In other cities, this form of retail activity is sometimes referred to as 'pop-ups' and they present a challenge to 'bricks and mortar' business establishments. Regulators and local government officers find them challenging because of their unconventional business *modus operandi*, their mobile nature, the difficulties that they pose in regulation, taxation, community complaints and the inevitable stress that they can bring to retailers and businesses in conventional premises. They defy convention. Many in the community, and tourists in particular, love the excitement, colour, vibrancy and diversity that they bring to a city’s streets. Essentially this chapter poses the question of whether we can use tools (i.e., GIS, the location of 311 complaint calls and various datasets) to enrich our understanding of vending and its regulations in New York City. Perhaps not unsurprisingly, the data available on vending in New York City focuses on violations (usually initiated through citizen complaints) and the locations of venders. A model is developed that examines for particular segments of New York’s city streets whether there were correlations between the rate of violations by street venders with property values or types of urban densities. Qadri asks the question about whose voice should be heard in regulating and enforcing street vending. Although this study is more exploratory than definitive on what elements result in concerns about street vending in Manhattan, the work is robust and demonstrates strongly the value of tools and smart city approaches to improve the management of street vending. Great cities value a diversity of experiences, and accommodating activities such as street vending, providing that it can be managed smartly, would raise the interest of many cities.

Ehsan Sharifi and co-authors *Alpana Sivam*, *Sadasivam Karuppannan* and *John Boland* demonstrate in Chap. 24 the use of Landsat 7/8 satellite surface cover temperature data to investigate their contribution to the analysis of the Urban Heat Island (UHI) effect in Adelaide, Australia. With much of the world’s population becoming urbanized, a critically important issue is how we can plan and manage development in cities to minimize the UHI effect, a proven phenomenon whereby hard surfaces such as concrete absorb heat which elevates the ambient temperature of micro-climates in urban areas by up to 4 °C. This research utilized Landsat imagery on days of local weather extremes (including selected days when on one occasion the ambient air temperature at ground level reached a maximum of 45 °C and on another occasion, there was an overnight minimum of 3 °C) to determine various surface material temperatures such as water, various types of vegetation, asphalt, paving and natural hard surfaces. Perhaps not surprisingly, water surfaces were coolest followed by vegetation. The implications for urban planning and management in the quest for planning smarter, more resilient cities to the heat stresses of a warming world are that planners now have in Landsat imagery an incredibly powerful instrument that diagnoses hotspots in the urban fabric. From a proactive point of view, Landsat can also just as easily be used in the early planning stages, prior to development to ensure that the optimal balance of surfaces to minimize the UHI effect is incorporated into a future development. The use of Landsat data as a proactive tool to minimize the UHI effect as an example of evidence-based planning presents a much stronger case to the community, policy-makers, developers and those in government of the difference that the use of Landsat can make to tackling the effects of climate change and in helping to make cities more pleasant places to live in.

Chapter 25 by *Takuya Oki* and *Toshihiro Osaragi* reports on an agent based modelling system that examines urban vulnerability in Japan, specifically to earthquakes and the fires associated with earthquakes. This work is an excellent example of a PSS being used to investigate policies that improve urban resilience in innovative ways to create a smarter city. The three mitigation policies include mandating fire extinguishers in all buildings, mandating seismic sensors that trip electrical power circuits in all buildings when tremors are detected and evaluation of a street network's performance to ensure clear pathways after an earthquake. The work also includes 'what if' scenario testing where changes to the street network are modelled, such as what might occur with street widening. The capacity of such models to estimate property damage and casualties associated with a particular policy action makes it an essential planning support tool in earthquake prone areas, minimizing the disruption that inevitably accompanies a catastrophic earthquake event.

In Chap. 26, by *Kiichiro Kumagai*, *Hitoshi Uematsu* and *Yuka Matsuda*, an advanced approach was developed to analyse the spatial continuity of vegetation distributions using the Osaka prefecture in the Kansai District of western Japan as a case study. Continuity of vegetation in urban areas is of crucial importance to maintaining biodiversity in urban areas because it supports wildlife and plant species by facilitating much larger habitats than would be possible with small fragmented randomly distributed vegetated areas. Often contiguity in vegetated corridors correlates with a natural feature such as a riparian environment, wetland, coastline or ridge-line. However, in urban areas where natural features are not so prominent or where there are intense development pressures, vegetated areas can be lost, particularly if there is an absence of strong land-use planning controls. Contiguous vegetated areas are also vitally important to human health in urbanized areas, and the authors note that with Japan as an aging society with a declining population, green spaces are part of a government strategy to avoid urban decay and compromised quality of life. Part of this is achieved by identifying redundant urban land that can potentially be converted to green spaces, preferably in a manner that ensures that a continuous and integrated open space system is achieved. This research utilized remote sensing using Landsat OLI data with statistical testing of the Normalized Difference Vegetation Index (NDVI). The researchers examined the relationship between the assessed values of land and geographic information to ascertain the extent to which proximity to vegetation impacts on urban and sub-urban land prices.

As a final chapter of the book, Chap. 27 starts from the observation that whilst the number of smart city projects and applications has increased substantially in recent years, empirical insights into the extent to which different smart city aspects are factually applied are really missing. *Lisanne de Wijs*, *Patrick Witte*, *Daniel de Klerk* and *Stan Geertman* aim to shed light on the state-of-the-art in smart city applications at different scale levels, based on a predominantly quantitative empirical analysis. Thus, in addition to a literature review, an enquiry was conducted among municipalities in The Netherlands in which questions were asked of government practitioners of Dutch municipalities concerning knowledge of and ambitions in the field of different aspects of smart city initiatives. The results show that both in The Netherlands and worldwide there are huge ambitions to develop and implement smart city applications, but that to some extent actual activities are lagging behind. Reasons for this mostly relate to lack of awareness of the possibilities and lack of financial and political priority; this is especially true for smaller-sized cities. Furthermore, it is shown that some smart city aspects like smart mobility and smart environment are receiving attention much more than some other aspects such as, for instance, smart governance. It is expected that when this will be resolved, actual activities will be more likely to live up to the huge ambitions regarding the smart city concept that many commentators suggest exist.

4 Conclusions

In this volume readers are taken on a journey into the world of Planning Support Science which seamlessly flows into the world of smart urban futures where big data, city analytics and visualization approaches to real-time information provided through open data feeds and social media are becoming increasingly common. At the beginning of this introductory chapter we have set the scene with a number of global challenges as the human population continues to expand across the planet in a time of rapid urbanization. Specifically we are faced with challenges such as increasing numbers of people living in slums, demographic restructuring, increases in extreme events, declining air quality, increases in traffic congestion, and global health crises with respect to obesity and associated diseases such as type II diabetes as well as famine and undernourishment.

It is therefore timely that we see the maturing of PSS where the focus has previously been on technology development to the evolution of Planning Support Science (Geertman 2013). Likewise, in recent times, we have witnessed the rise of both city science and data science which, when combined with Planning Support Science, provide a strong underpinning to the emergence of the smart city concept. The chapters in this volume discuss a combination of innovative PSS methods, techniques and case studies which can arm the next generation of planners with the ability to tackle the global challenges head on and endeavour to make our cities more sustainable, productive and resilient.

References

Allen, E. (2001). INDEX: Software for community indicators. In R. K. Brail & R. E. Klosterman (Eds.), *Planning support systems* (pp. 229–261). Redlands, CA: ESRI Press.

Allen, E. (2008). Clicking toward better outcomes: Experience with INDEX, 1994–2006. In R. K. Brail (Ed.), *Planning support systems for cities and regions* (pp. 139–166). Cambridge, MA: Lincoln Institute of Land Policy.

Arciniegas, G., Janssen, R., & Rietveld, P. (2013). Effectiveness of collaborative map-based decision support tools: Results of an experiment. *Environmental Modelling and Software, 39,* 159–175.

Batty, M. (1995). Planning support systems and the new logic of computation. *Regional Development Dialogue, 16,* 1–17.

Batty, M. (2013). *The new science of cities*. Cambridge, MA: The MIT Press.

BITRE. (2015). Traffic and congestion cost trends for Australian capital cities. *Information Sheet 74, Bureau of Infrastructure, Transport and Regional Economics, Department of Infrastructure and Regional Development, Commonwealth Government, Canberra*. Accessed February 12, 2017 from https://bitre.gov.au/publications/2015/files/is_074.pdf

Couclelis, H. (2005). "Where has the future gone?" Rethinking the role of integrated land-use models in spatial planning. *Environment and Planning A, 37*(8), 1353–1371.

da Silva, J. (2016). *City resilience index*. ARUP. Accessed February 2017 from http://publications.arup.com/publications/c/city_resilience_index

FAO. (2015). The State of food insecurity in the world. In *Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress*. Rome: FAO. Accessed February 21, 2017 from http://www.fao.org/3/a-i4646e.pdf

Geertman, S. (2006). Potentials for planning support: A planning-conceptual approach. *Environment and Planning B: Planning and Design, 33,* 863–880.

Geertman, S. (2013). Planning support: From systems to science. *Proceedings of the Institution of Civil Engineers: Urban Design and Planning, 166*(1), 50–59.

Geertman, S., Ferreira, J., Goodspeed, R., & Stillwell, J. (Eds.). (2015). *Planning support systems and smart cities*. Lecture Notes in GeoInformation and Cartography. Dordrecht: Springer.

Geertman, S., & Stillwell, J. (Eds.). (2003). *Planning support systems in practice*. Advances in Spatial Science. Berlin: Springer.

Geertman, S., & Stillwell, J. (Eds.). (2009). *Planning support systems best practice and new methods.* The GeoJournal Library 95. Dordrecht: Springer Science & Business Media.

Geertman, S., Toppen, F., & Stillwell, J. (Eds.). (2013). *Planning support systems for sustainable urban development*. Lecture Notes in GeoInformation and Cartography. Heidelberg: Springer.

Harris, B., & Batty, M. (1993). Locational models, geographic information and planning support systems. *Journal of Planning Education and Research*, *12*(3), 184–198.

Klosterman, R. E. (1997). Planning support systems: A new perspective on computer-aided planning. *Journal of Planning Education and Research, 17,* 45–54.

Klosterman, R. E. (1999). The What if? collaborative planning support system. *Environment and Planning B: Planning and Design, 26,* 393–408.

Kwartler, M., & Bernard, R. (2001). CommunityViz: An integrated planning support system. In R. K. Brail & R. E. Klosterman (Eds.), *Planning support systems* (pp. 285–308). Redlands: ESRI Press.

Lee, D. B. (1973). Requiem for large-scale models. *Journal of the American Institute of Planners, 39*(3), 163–178.

Marsden, R. (2015). A web-based information system for planning support in Barnsley. *Applied Spatial Analysis and Policy, 8*(2), 131–153.

Pettit, C. J., Barton, J., Goldie, X., Sinnott, R., Stimson, R., & Kvan, T. (2015a). The Australian urban intelligence network supporting smart cities. In S. Geertman, J. Ferreira, R. Goodspeed, & J. Stillwell (Eds.), *Planning support systems and smart cities* (pp. 243–259). Lecture Notes in GeoInformation and Cartography. Dordrecht: Springer.

Pettit, C. J., Klosterman, R. E., Delaney, P., Whitehead, A. L., Kujala, H., Bromage, A., et al. (2015b). The online What if? planning support system: A land suitability application in Western Australia. *Applied Spatial Analysis and Policy., 8*(2), 93–112.

Pettit, C. J., Klosterman, R. E., Nino-Ruiz, M., Widjaja, I., Tomko, M., & Sinnott, R. (2013). The online what if? Planning support system. In S. Geertman, F. Toppen, & J. Stillwell (Eds.), *Planning support systems for sustainable urban development* (pp. 349–362). Lecture Notes in GeoInformation and Cartography. Heidelberg: Springer.

Pettit, C., Tice, A., & Randolph, B. (2017). Using an online spatial analytics workbench for understanding housing affordability in Sydney. In P. Thakuriah, N. Tilahun, & M. Zellner (Eds.), *Seeing cities through big data: Research, methods and applications in urban informatics* (pp. 233–255). Cham: Springer International Publishing.

Rockefeller Foundation. (2015). *100 Resilience*. Accessed February 2017 from https://www.rockefellerfoundation.org/our-work/topics/resilience/

Russo, P., Costabile, F. M., Lanzilotti, R., & Pettit, C. J. (2015). Usability of planning support systems: An evaluation framework. In S. Geertman, J. Ferreira, R. Goodspeed, & J. Stillwell (Eds.), *Planning support systems and smart cities* (pp. 337–353). Lecture Notes in GeoInformation and Cartography. Dordrecht: Springer.

Sanderson, D. (2016). Urban disaster resiliences: New dimension from international practice in the built environment. In D. Sanderson, J. Kayden, & J. Leis (Eds.), *Urban disaster resilience* (pp. 3–15). New York: Routledge Taylor & Francis Group.

Thakuriah, P. V., Tilahun, N. Y., & Zellner, M. (2017). Introduction to seeing cities through big data: Research, methods and applications in urban informatics. In Thakuriah, P. V., Tilahun, N. Y., & Zellner, M. (Eds.), *Seeing cities through big data: Research, methods and applications in urban informatics* (pp. 1–9). Cham: Springer International Publishing.

The Guardian Website. (2016). *Smog refugees flee Chinese cities as ‘airpocalypse’ blights half a billion*. Accessed February 15, 2017 from https://www.theguardian.com/world/2016/dec/21/smog-refugees-flee-chinese-cities-as-airpocalypse-blights-half-a-billion

UN Habitat. (2003). *The challenge of slums: Global report on human settlements, United Nations Human Settlements Programme*. London: Earthscan.

United Nations. (2014). *World urbanization prospects: The 2014 revision, highlights*. New York: United Nations Department of Economic and Social Affairs, Population Division.

United Nations. (2016). *The World’s Cities in 2016—Data Booklet (ST/ESA/ SER.A/392)*. New York: United Nations, Department of Economic and Social Affairs, Population Division. Accessed February 15, 2017 from http://www.un.org/en/development/desa/population/publications/pdf/urbanization/the_worlds_cities_in_2016_data_booklet.pdf

Vonk, G., Geertman, S., & Schot, P. (2005). Bottlenecks blocking widespread usage of planning support systems. *Environment and Planning A, 37*(5), 909–924.

Waddell, P. (2002). UrbanSim: Modelling urban development for land use, transportation, and environmental planning. *Journal of the American Planning Association, 68*(3), 297–314.

World Bank. (2016). *The cost of air pollution: Strengthening the economic case for action*. Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/781521473177013155/The-cost-of-air-pollution-strengthening-the-economic-case-for-action