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Design to Thrive

Critical mapping for transformational cities

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Abstract: Cities are currently under threat of many disruptive factors, such as climate change, migration, security, terrorism and economic disparity. The future of the city will not turn out to be one-dimensional. Instead cities will become more and more complex and adaptive systems. To get grip on the future of cities this paper presents a framework of mapping a suite of archetypical cities, which once they are brought together again show their interdependencies, multipliers and synergies. The mapping is done on the basis of a set of indicators, specific for each 'city'. Once these metrics are known the maps can be built and the interdependencies between them can be found. Each of the archetypical cities as well as the entire framework is set-up as collaborative research between the university and urban stakeholders and between a maximum of five cities around the world. This allows for a fundamental comparison between the cities on the basis of the identified metrics. The paper discusses the sets of indicators and metrics for each city and the opportunities that the framework offers to enhance critical reflections on the individual layers as well as the interrelations between the layers. The overlayed mappings provide critical information as to where the strategic interventions for creating more resilient and sustainable urban environments are located. The paper offers insights into the way future cities might develop with respect to each of the themes, but also as an integrated complex urban system.

Keywords: resilient urban design, framework for urban design, layer approach, identity, sustainability

Introduction

Design of the future can no longer be based on the certainty of programs and conditions. In order to address ever changing conditions and shifting programs, a plan for a city or precinct has to reflect its own conditions and the effects of the planned interventions and the process of planning has to be transformed into a reflexive process (Beck, 1994) of multiple feedback. Secondly, climate change, migration, even economics and social processes comprise the so-called wicked problems (Rittel and Webber, 1973) which need to be continuously treated and directed to create a better future. With no single, accepted formulation of these problems, the answers are often defined in "more-or-less" terms in which planners and managers at best can find reasonable, but shifting balances among competing interests and values. These persistent problems require counterintuitive thinking, and the development of new knowledge. Design is a very suitable approach for these types of problems (De Jonge, 2009). Creative thinking, problem solving and design innovations enable the integration of a large number of partial solutions into a spatial strategy for a city and its suburbs, linking these up with various activities and interventions (Rosemann, 2001)

In the meantime, many aspects that influence life on earth, and especially in cities, are changing and unprecedented. We distinguish three types of uncertainty that impact cities more than these planning frameworks can deal with:

(i) Uncertain developments that face uncertainty from wicked problems of climate change, migration and technological developments (Commonwealth of Australia 2007);

(ii) Enforced uncertainties such as the transition towards a green economy (Allen and Clouth 2012) or a low-carbon energy supply (Foxon et al. 2010) that are deliberately enforced

(iii) Increased exposure to uncertainties such as increased global population especially in vulnerable locations (Kreimer et al. 2003).

Figure 1. Middleton, Western Sydney (Google Maps)

The complexity of current problems and the diverse types of uncertainty we have to deal with makes the case for transformative design. However if we continue to let the priority for economic benefits to drive urban delivery - the resulting neighbourhoods (Figure 1) show suboptimal results in terms of resiliency and sustainability. They suffer from heat, lack of tree cover, flash flooding, and there is hardly any space for green-water or ecological structures.

In the case of Sydney, the creation of "vibrant attractive and well connected communities" is a recurring theme in a range of draft plans and policies developed by the NSW Government Planning and Environment (e.g. Kellyville/Camellia). In these cases, whether new land releases or urban infill, the main stay of these plans arises from land use, infrastructure and transport analyses that primarily address key economic and growth drivers – population growth, density, jobs, their location and future, and requirements for transport connectivity in the city. In most situations broader environmental concerns for such aspects such as water, ecology, soil, and elevation tend to have limited bearing on urban morphology, master planning at precinct level and individual design of houses.

A planning framework is needed to understand how an alternative way of delivering urban neighbourhoods can lead to a more sustainable, resilient and interesting places. Several attempts to make green cities are evident in the literature: These include ambitious "game changer" projects developed to showcase sustainability and the notion of a top down approach to green urbanism such as Masdar City or Dongtan. Much of the additional housing needs to be found through retrofitting suburbia. Several are developed as green urban redevelopments of existing neighbourhoods, such as BedZed in London, Central Park in Sydney, or as exemplary circular city development, e.g. Buiksloterham in Amsterdam.

Approach

We have analysed three ways of (green) urban planning, each driven by their own rules.

1. The 'developer' rules: A straightforward economic model. Land prices, development models and land ownership determine the outcome and typologies of urbanism.

2. The 'policy' rules: A separated way of increasing sustainability by adopting thematic plans for energy, water, etc. The high ambitions of each of these plans often do not come to fruition as in reality they conflict with other plans f urban development.
3. The 'crowd' rules: Integrated resilience thinking. In this model the individual domains are designed to the maximal resilient level. After this the position in these domains of specific areas (neighbourhoods/precincts) determines the combination of requirements from each of the domains. This gives the area a specific uniqueness and distinction from its neighbours. As result a field of qualities emerges, which altogether form an interconnected resilient system.

Having explored these three models of development, we have chosen the third model as the basis for resilient and green urban design. For this model we have developed a planning and design framework, which is able to provide resilience and diversity on all levels of the city. The idea behind the framework is to deconstruct the cities complexity in several layers, which, each by themselves, are designed in the most resilient way. When we then reconnect the different layers in the design for a local area, so that the end result is a unique combination of sourced layers - distinctive of place and containing a high level of resiliency. The framework is under construction and therefore we elaborate only on the energy layer at three levels to indicate how the framework works in this paper.

Preliminary findings: the energy layer

We explore the manner in which considerations for energy are addressed and influence the making of the city at three levels to illustrate current approaches and the potential of our proposed framework.

Status Quo - What is achieved at the household scale

In the Australian context, the Building Code of Australia (ABCB]. (2014) stipulates energy efficiency measures with the express goal of reducing potential greenhouse gas emission from space conditioning of buildings. These requirements essentially regulate the thermal performance of the building envelope (roof, wall, floor, windows) while taking into account shading and ventilation. Energy efficiency in houses is also reinforced through minimum standards for ductwork of heating and cooling systems, plumbing, water heating and artificial lighting with opportunities in some jurisdictions to gain credits for efficient (low greenhouse gas impact) forms of heating cooling hot water and alternate energy systems.

The legislations and targets embody a tacit acknowledgement of market forces-all stringency limits were determined through detailed cost benefit analysis to ensure compliance costs could be offset through the potential energy savings. Introduction through BASIX regulatory scheme has resulted in 64% of dwellings exceeding their energy targets when compared to average NSW houses NSW Department of Planning (2011)

At a site/precinct level, the minimum performance requirements for thermal envelope and services are overlaid with local development control plan (DCP) regulations for amenity -solar access, overshadowing, daylight and opportunity for natural ventilation. Coupled with controls for the architectural treatment of dwelling facades, a fairly homogenous quality of housing stock is evident in many new suburbs in Sydney. Rather than the homogeneity in aesthetics, what is of concern is the underlying assumption of no difference in layout, built form or materiality to address variation in temperature, occurrences of extreme weather or flooding, whether they be close to the coast or 100 km inland (Figure 2). Another point to note is that the existing framework is designed on the assumption of

uninterrupted supply of non-renewable energy (electricity and gas) from the grid in all locations. Most typical developments pay little attention to the questions of precinct wide management of peak electricity demand, and resilient infrastructure for an energy secure future.

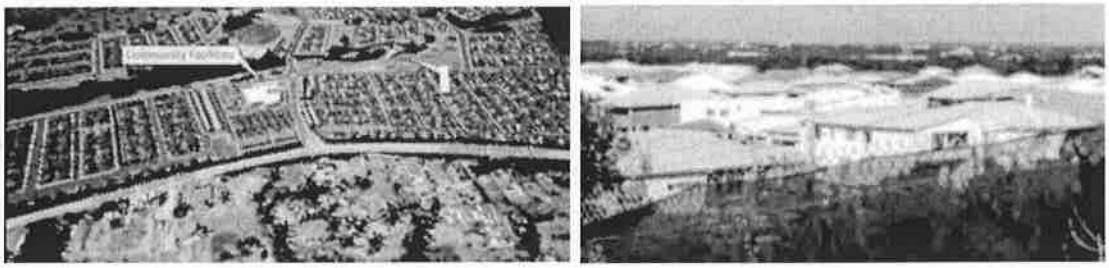

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Figure 2: Basix Compliant developments – a. Kelly Ville and b. Green Hills Beach

In comparison, a greater awareness of the broader questions of resilience from an energy perspective is evident through many recent building and precinct developments (such as Central Park in Sydney or Alkimos Beach in Western Australia; Tonsley Park in South Australia that consider reduced peak Electricity Demand, On-site generation and Energy Storage aspects that are rewarded to precinct via rating tools such as Green Star Communities (GBCA 2017). In most of these cases, the impetus for these projects arise from the setting of ambitious and aspirational goals of state /local authorities and developers keen to promote flagship demonstration projects. Often in these cases, the tacit knowledge of local energy networks and infrastructure and data of performance remains outside the public domain.

Status Quo - What is achieved at the regional scale

Energy network data that is typically available to planners and developers emphasises the electricity grid and gas networks as the primary sources of energy in our cities (Figure 3).

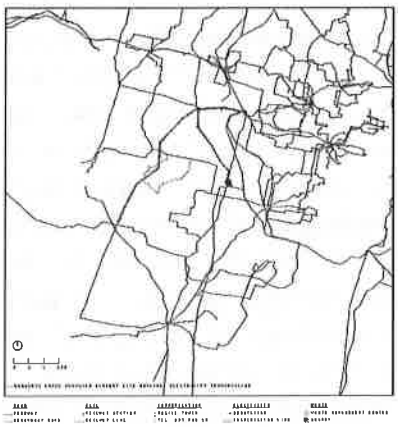

Figure 3. Grid-from GIS mapping– image electricity grid. Source: March studio GO WEST! – Holly Johnson, Megan Johnson student extracted map as part of studio investigations, 2017 – Studio Leader Rob Roggema and Craig Allchin

Figure 4: Clean Energy in the Sydney Metropolitan region (Clean Energy Council, 2017)

What is missing in the regularly available data at the precinct scale is information relating to local storage, trigen plants, local smart grids, local solar and wind farms. Although available from other sources (Clean Energy Council, 2017) data regarding renewable energy sources (see Figure 4) are static, retrospective and not immediately considered to our knowledge in the mainstream planning domain. Alongside the basic information of electricity infrastructure for a given precinct (See Figure 5 a), any information relating to storage opportunities, exposition and radiation, wind that are determined by the local context (Figure 5 b) is required to be mined and understood separately

Where to from here - Integrated resilience thinking

The advantages of Energy Potential Mapping to visualise mismatches, surpluses and shortages of energy and to develop Energy Master plans to assist planning strategy is well documented (Roggema et al., 2011, Dobbelsteen et al 2014). This approach has been used to develop a Trigeneration Master plan for Sydney (Kinesis 2013).

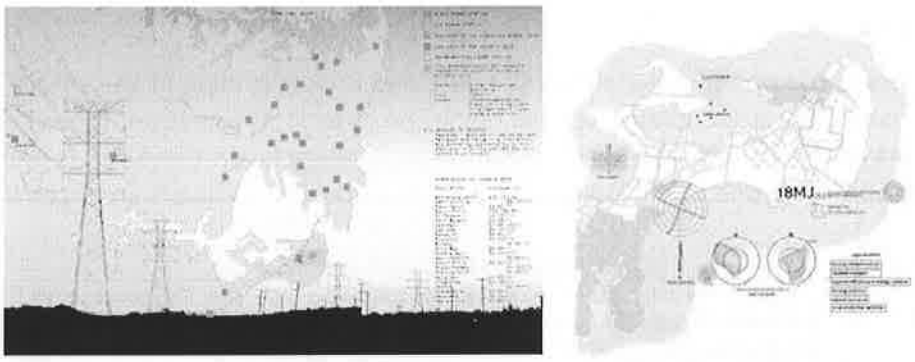

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Figure 5.Student mapping of Kurnell Peninsula showing (a) Electricity infrastructure and (b) Energy Potential Mapping [Source: M.Arch Studio Project 2013 Refining Kurnell - (a) Nason, K., Swinburne, A., Calabrese, D., Salinas, S., Gatesoupe, A. and (b) ,– Studio Leader Leena Thomas and Amelia Holliday

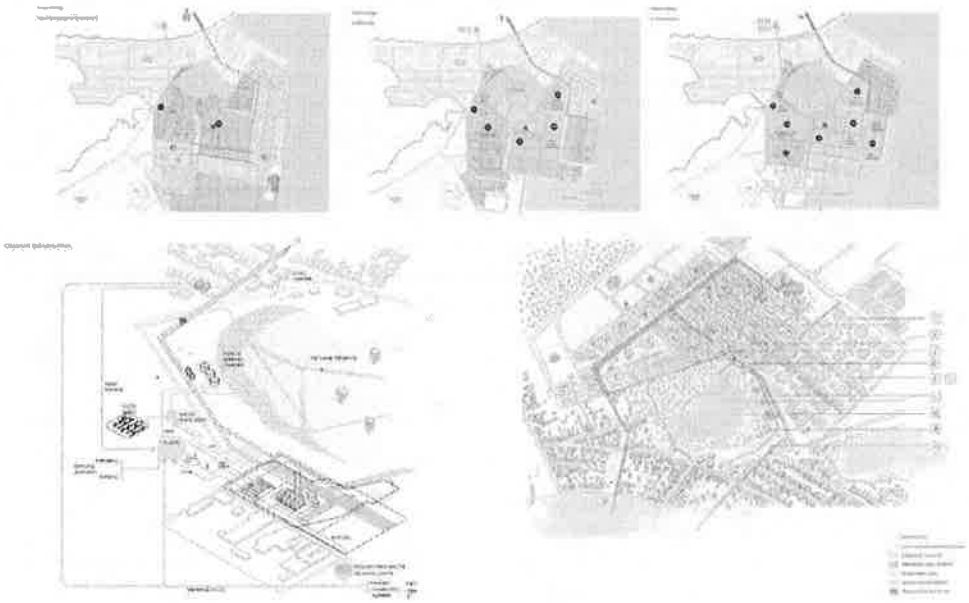

Figure 6. Student group precinct strategy for the post-oil transformation of fuel import site at Kurnell. (Source: M.Arch Studio Project - Capparelli, J., Ferriere, M., Kacha, K., Trudeau, T., Zarsav, S., 2014 – Studio Leader Leena Thomas and Jarrod Lamshed).

Using an integrated approach it becomes possible to conceptualise a highly resilient energy system towards the ambition of a Zero Carbon City at the precinct level, connected with eventual extra storage and backup capacity at the regional scale (windfarms, hydro), and minimising demand at the household level that is site and context specific. This could also combine with other considerations such as on- site bio-energy, food production and waste treatment, to develop an intelligent precinct strategy as evident in this speculative masters studio project for the transformation of a former brownfield oil refinery site into a sustainable living and work environment (Figure 6).When rolled into practice, such an approach should necessarily combine aspects of smart metering for feedback, demand management, citizen engagement and other aspects to capture behavioural change. As discussed above, rigorous and critical mapping of the inputs, outputs and opportunities within the energy layer has the potential for transformative design of the city. Importantly it enables interrogation of the assumed dependency on a fossil fuel based energy network and provides an operational framework to shift to a resilient energy system.

The framework

As the analysis of the energy layer shows the data and understanding of the energy layer as a resilient system is not complete. Besides filling the gaps in information, the energy layer should be designed as a fully renewable, zero-carbon energy layer. Once this is undertaken the energy layer forms one of the layers of the framework. The 15 layers are listed in table 1:

Table 1: 15 Layers of resilient Sydney

Zero Carbon Sydney	use of renewables, generate energy in or around the city. More energy generated than is used, create a Carbon Sink, use the method of energy potentials mapping (Roggema et al., 2011; Dobbelsteen et al., 2013).
Sydney with more bikes than cars	reduce the space for cars, increase public spaces, bike infrastructure - after Copenhagen (Cathcart-Keays, 2016)
Disaster free Sydney	resilient for climate hazards. No-impact of floods, fires, rain events, Urban Heat Island effect, water sensitive design, fire sensitive design, etc. Swarm Planning (Roggema, 2012) as an approach to create more flexibility in cities and create resilience (the resilient city, socio-ecological systems, socio-technological systems, complex adaptive systems, disaster risk management)
Sydney Smart by Nature	Consider the city as an organism with different functions, organs, body elements, does it suffer from viruses, illness, does it eat well. Make the city flexible in changing its shape. Use self-organisation, complexity, systems thinking. Urban informatics, Smart urban environments, robotics, data driven design, interactive design (Oosterhuis, 2012).
Sydney Food Region	urban agriculture, grow food for the population of Sydney, within in and around the urban boundaries, food region. Minimise foodmeters and foodmiles. (Wascher et al., 2015)
Metabolic Sydney	flows of materials, energy, water, information, how much comes in and leaves, how is it processed within, recycle, re-use, circular economy, flows and the metabolism of cities (Wolman, 1965), Extended urban metabolism model (Newman, 1999), Cradle to Cradle (McDonough and Braungart, 2009
Affordable Sydney	create a city in which everyone can live, in places where they want. Prevent a push out of the centre for citizens that are less wealthy, housing
Equitable Sydney	a city in which everyone gets the same chances, there is no distinction between people on the basis of gender, race, age
Healthy Sydney	access to green, air quality etc.
Inhabitable Sydney	When worse comes to worst, people can't afford to live here anymore, disaster cannot be prevented, climate is too harsh.
Sydney as an Urban Landscape	how does the landscape determine the city. How does the soil, water system, elevation and microclimate define urban patterns, urban use. (Weller, 2009), Design with nature (McHarg, 1969), ecological urbanism, landscape urbanism (Waldheim, 2016), regional ecological model (Roggema et al., 1994)
DenSydney	how can the density of functions, urban land-use, housing, and population be increased? How,

	what kinds of new qualities could it deliver? How many additional houses, could be delivered, which are the architectural typologies fitting with this strategy?
Datasydney	City designed completely based on data. What happens? Computational design. What are the parameters? Price/land value (affordability), safety (climate hazards/criminality), diversity (people/income), efficiency/transport, traffic flows, the city sensored, measured.
Post industrial Sydney	what happens with all the spaces that will no longer be used for industrial activities, mining, refineries, power plants. (Thomas 2015) Where are these spaces located, how to regenerate. Less space required for mobility/cars. Free falling infrastructure space; what to do with it. How to redesign re-use?
Sydney of Infrastructures	resource and waste infrastructure, transportation infrastructure (road, train, water), water management infrastructure, energy infrastructure, communication infrastructure. How do we value network connectivity (Thomas et. al 2015) and how are the infrastructure systems linked?

These layers are partly aligned with the environmental strategy of the City of Sydney (http://sydneyyoursay.com.au/environmental-strategy/documents/37740/download). In the framework we propose each layer to cover the entire metropolis. In this sense the set of layers deconstruct the diverse domains in separated resilient propositions. At the local level the specific qualities of each layer will be reconnected and provides the program of demands for the local design task.

Because the framework works at different scales, the collaborative power of a range of organisations and institutions is essential to deliver the highest possible resilience. The resolution of data, the accessibility and the dynamism of the data in order to provide the right data at the right scale at the right time, e.g. permanently, is also an essential factor that can make the framework a success.

Conclusion

Through combining the localised parts of every layer at its highest resilience performance, the result at the precinct scale will also be resilient, and at the same time will distinguish itself from their neighbours.

The model of resilient integrated urbanism will bring more values together than only the economic value, such as ecological values (energy, water etc), social values (identity, liveability), etc. In order for the framework to become practical, the barriers of data-collection, accessibility and sharing need to be resolved.

In an operational sense the framework is in line with the work of many regional authorities, which collect data and produce visions and policies for the region. In the context of Sydney, the Greater Sydney Commission is the organisation that best could adopt the framework, in order to put a mechanism in place that uses regional data for the benefit of resilient city planning.

The value of the proposed approach lies in the fact that regional authorities can start an evidence-based planning process for the future development of the metropolis. This way the coherence of the region, its resilience and the spatial differences are enhanced, which leads to a more attractive and thriving region.

References

Allen C, Clouth S (2012) A guidebook to the green economy. UNDESA, New York

Australian Building Codes Board [ABCB]. (2014). Section J: Energy Efficiency. In *Building Code of Australia 2014*. Canberra: Australian Building Codes Board.

Beck, U. The Reinvention of Polities: Towards a theory of reflexive modernization. In Reflexive Modernization: Polities, Tradition and Aesthetics in the Modern Social Order; Beck, U., Giddens, A., Lash, S., Eds.; Stanford University Press: Palo Alto, CA, USA, 1994.

Cathcart-Keays, A. (2016) Two-wheel takeover: bikes outnumber cars for the first time in Copenhagen. The Guardian, 30 Nov 2016. URL: https://www.theguardian.com/cities/2016/nov/30/cycling-revolution-bikes-outnumber-cars-first-time-copenhagen-denmark

Clean Energy Council, 2017 – Renewable Energy Map URL: https://www.cleanenergycouncil.org.au/technologies/renewable-energy-map.html

Commonwealth of Australia (2007) Tackling wicked problems; a public policy perspective. Australian government/Australian public service commission, Canberra

Dobbelsteen, A., Nico, T., Broersma, S., and Fremouw, M., (2013) The Energy Master Plan: Transition to self-sufficient city regions by means of an approach to local energy potentials in Proc. 30th PLEA Conference - CEPT University Press, Ahmedabad, India.

Foxon TJ, Hammond GP, Pearson PJ (2010) Developing transition pathways for a low carbon electricity system in the UK. Technol Forecast Soc Chang 77(8):1203–1213

GBCA 2017 Green Star Communities Rating tool http://new.gbca.org.au/green-star/rating-system/communities/ accessed 1 April 2017

Kinesis (2013) The *Decentralised Energy Master Plan – Trigeneration* 2010–2030. March 2013. Sydney: The City of Sydney. URL http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0007/193057/Trigeneration-Master-Plan-Kinesis.pdf

Kreimer A, Arnold M, Carlin A (eds) (2003) Building safer cities: the future of disaster risk. The International Bank for Reconstruction and Development/The World Bank, Washington

McDonough, W. Braungart, M. (2009) *Cradle to cradle: Remaking the way we make things*. London: Vintage

McHarg, I. (1969) Design with Nature. New York: Natural History Press

Newman, P.W.G. (1999) Sustainability and cities: extending the metabolism model. *Landscape and Urban Planning* 44 219-226

NSW Department of Planning (2011) 2006-09 Multi-Dwelling Outcomes BASIX Ongoing Monitoring Program. Sydney: NSW Department of Planning.

Oosterhuis, et al. (2012) Hyperbody: First Decade of Interactive Architecture. Jap Sam Books

Rittel, H.;Webber, M. Dilemmas in a General Theory of Planning. Policy Sci. 1973,4, 155-169.

Roggema, R. (2012) *Swarm Planning: The development of a Methodology to Deal with Climate Adaptation*. Delft, Wageningen: Delft University of Technology and Wageningen University and Research Centre. PhD-thesis

Roggema, R., A. van den Dobbelsteen, S. Stremke and W. Mallon (2011) Spatial-energy Framework Aiming at Breakthroughs Brings Goals Beyond Policy Objectives within Reach'. In: A.J. Jenkins (Ed.) (2011) Climate Change Adaptation: Ecology, Mitigation and Management. New York: NOVA Publishers, pp.127-150.

Rosemann, J. The Conditions of Research by Design in Practice. In Research by Design, International Conference Proceedings. The Netherlands, 1–3 November 2000; Van Ouwerkerk, M., Rosemann, J., Eds.; Delft University Press: Delft, The Netherlands, 2001; pp. 63–68.

RUAF and FAO (2015) City Region Food Systems. Building sustainable and resilient city regions. URL: http://www.fao.org/3/a-i4789e.pdf

Thomas, L.E. 2015, 'Rethinking architecture as a catalyst for sustainability', Proc. 49th International Conference of the Architectural Science Association, Melbourne, pp. 836-845

Thomas, L.E., Rickwood, P. & Dilevska, J. 2015, 'The Carbon Cost of Work—Impacts of Office Building and Commuting Energy in Sydney Workplaces', *Urban Policy and Research*, vol. 33, no. 3, pp. 340-361.

United Nations (2008) World urbanization prospects. The 2007 revision. Executive summary. United Nations, New York

Waldheim, C. (2016) Landscape as Urbanism. A general theory. New Jersey: Princeton-University-Press

Wascher, D.M., Piorr, A., Pintar, M....., van Eupen, M. (2015) FOODMETRES – Metropolitan food planning connecting the local with the global. *Urban Agriculture Magazine* 29 41-44

Weller, R. (2009) Boomtown2050: Scenarios for a Rapidly Growing City. Perth:UWA Publishers

Wolman, A. (1965). The metabolism of cities. *Scientific American*, *213*(3), 179-190.