An examination of how cities around the world that have managed to achieve rapid transformation to implement smart strategy: Assessing the driving factors and governance to preventative, reactive, developing and future strategy to environmental hazards

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Author's Declaration

I [8929456] confirm that this report is based on my own work and that I am happy with both my own and my partner's [9134588] contribution to the final submitted version.

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Abbreviations

ANM - Active Network Management

CHP – Combined Heat and Power

CROP – Cepat Respon Opini Publik

DERM – Distributed Energy Resource Management

ESCO – Energy Service Company

GI – Green Infrastructure

GM – Greater Manchester

IPP – Independent Power Producer (often private entrepreneurs)

LIPA – Long Island Power Authority (LIPA)

MG – Microgrid

NYSERDA – New York Energy Research and Development Authority

NYPA – New York Power Authority

NGOs – Non-Governmental Organisation

NYTO – New York Transmission Owners

NYISO – New York Independent System Operator

PSC – Public Service Commission

ULL – Urban Living Laboratory

US – United States

Executive Summary

This report discusses the increasing usage of information technologies by cities as a way of combatting environmental change and raising their resilience. Natural hazards such as earthquakes and flooding are often the main triggers for authorities to be forced to find new ways to adapt, due to their current infrastructure and way of thinking not being totally conducive to a harmless and unaffected urban environment. Smart cities are innovative ways of creating such preventative, reactive, developing and futuristic ways to progress and protect urban areas. This report will assess a number of different-scaled smart city initiatives in New York, Christchurch, Jakarta and Manchester encompassing the use of microgrids, social media, smart energy meters and green travel. It also assesses the governance and citizen engagement that is an instigator and implementer of these strategies. The report concludes with recommendations for further collaboration and engagement between authorities, citizens, science and technology being the optimum way future smart city initiatives can become successful.

Introduction

One way resilience is realised is through the development of smart cities. Such cities rely on information and communication technologies to transform the urban environment in a progressive and sustainable way (Joss, 2016). Arup's mission statement, to shape a better world' reflects this. Through the involvement of planners, engineers and other specialists it aims to utilise transformative and innovative practices to deliver the benefits of smart cities and make a positive difference to the physical environment and societies (Arup, 2017).

Resilient smart cities, especially those which have been motivated by natural changes have many forms. This report will assess the ways by which four (New York, Christchurch, Jakarta and Manchester) have adapted to their own environmental changes to create, and implement, technologies that are preventative, reactive, developing and considerate of the future, respectively. Assessment of the involvement of stakeholders and citizens will be examined for without such involvement of such partners these projects would be likely to have minimal success or longevity.

Smart, resilient cities are revolutionary and paramount way for urban areas to protect themselves and mitigate the effects of the increasing environmental change. By understanding and evaluating current projects, an assessment of the positives and negatives are able to be identified, and recommendations for future projects will be able to be created.

Governance and Stakeholder Engagement

Seyfang and Smith (2007) describe city transformation as incorporating ecological modernization and technological innovation, encouraging niche community action to generate innovative smart concepts. Innovation is essential for meeting environmental change and limitations with governance changes important to achieve this (Coaffee and Healey, 2003**)**.

Additionally, community citizen engagement and governmental efforts, have proven to be successful (Coaffee and Healey, 2003). Conflict between government and citizen engagement can be explained via democratic and neoliberal governance (Lemke, 2001, Swyngedouw, 2005). However, institutions take an alternative approach reliant on 'rules, norms and practices which structure areas of social endeavour'.which control institutional norms (Coaffee and Healey, 2003: p. 1982). Governance involves establishing a 'method, identifying problems, negotiating cooperation and implementation of strategy', with individuals implementing these changes (Bevi and Rhodes, 1999; Schmitter, 2002:52).

Importance of Resilience and Governance

In a world where high levels of ecosystem change and environmental disturbances are increasingly commonplace, resilience is the favoured approach to incorporate science and technology to respond to and minimise the negative impacts on society and economy (Ahern, 2011).

Such an approach is achieved through planning and adaption of the urban environment through research, stakeholder participation, planning policies and innovative infrastructure (Ahern, 2011). This is preferred to forcing environmental adaptation to society based actions. Resilience thereby incorporates aspects of resisting disturbances (persistence), adapting to disturbances (transition) as well as radical change within urban environment allowing protection from future disturbances (transform) (Meerow et al, 2016).

Smart Cities

Smart cities involve socio-technical transformation whereby information and communication technology (ICT) is used to change the urban surface, systems and processes. The 'smart city encompasses:

- 'wired' (Dutton et al, 1987);
- 'cyber' (Graham and Marvin,1999);
- 'digital' (Ishida and Isbister, 2000); 'intelligent' (Komninos, 2002);
- 'smart' (Hollands, 2008)
- 'sentient' (Shepard, 2011)

Infrastructural inputs within smart cities consist of a flow between sensors, distribution, management, storage, advanced power electronics and communication technology (Frost and Sullivan, 2016). Smart cities deploy sensor based ubiquitous computing across urban infrastructure, although with the potential to delimit urban citizenship, imagining citizens within smart city strategy is essential (Gabrys, 2014).

Smart cities are increasingly linked with sustainable cities (Joss, 2016: 6). Initially raised at the Rio earth summit (1992) as a route to sustainability and the tackling of growing urbanism, its role has increasingly been questioned. Martin et al (2016: 2) suggest 'the ability of smart technology to deliver sustainability remains little more than an article of faith'.

The concept of 'smartness' reinforces entrepreneurial form within socio-economic urban development (Hollands, 2008). Neo-liberal thinking is embedded in smart cities, offering the opportunity for digital economic growth in parallel to social equity (Caragliu et al, 2011; Martin et al, 2016). However, the 'sustainable city' approach via technological modification of information and infrastructure also leads to a 'smart city' (Joss, 2016; Gargiulo et al.,

2013; Viitanen and Kingston, 2014; De Jong et al., 2015). Martin et al (2016) suggests a shift in urban planning priorities favouring a capitalist growth model required for the achievement of a smart city.

Schaffers et al (2011: 437) states a smart city is driven by technology corporations with 'smart city solution's more vendor push than city government pull based'. However, this often leads to a technical 'lock-in' where cities are focused towards particular technological platforms benefiting corporation rather than community. Alternatively, the 'leapfrogging' concept advances technological innovation to futuristic ideas (Yu and Gibbs, 2017). Often this can lead to a 'black box' approach to smart city development, focusing more on economic advantages and taking little account of city uniqueness and adaptive approaches (Kibchin, 2013).

Technology companies can play an important part in cultivating smart cities through the introduction of technological advances (Mullagh et al, 2014). Within urban development their growing profile suggests a shift from traditional planning techniques toward new technological practices to improve quality of life, strengthen the city's economy, and protect the environment' (Arup, 2014; Martin et al., 2016).

Citizen engagement is key to a successful smart city concept (Evans et al, 2016). However, research shows minimal awareness by those who are citizens of smart cities with work with only a third of the population familiar with the term (Frost and Sullivan, 2016).

Urban Living Laboratories (ULLs) and experimental cities

Cities are facing new challenges, which force them to become increasingly open to innovation and creativity (Evans et al, 2016). Urban living laboratories have emerged as a way that governments can introduce and control smart strategies (Evans and Karvonen, 2014). The post-positivist theory of an ULL postulates the urban community benefitting from economic growth and cohesion as well as reaping socio-technical advances (Karvonen et al, 2014). Experimental cities also offer strong links between institutional actors through governance and political engagement with change induced via instruments, materials and people without compromising lifestyle norms (Evans et al, 2016).

Research Objectives

The objectives of this review are to:

1. Understand to what degree have environmental factors driven rapid smart city transformation?
2. Assess how does a smart city strategy differ depending on how a project is implemented?
3. Evaluate stakeholder interaction across smart city projects
4. Assess differences in policy to achieve a strategy for smart cities.

Approach in Methodology

- Smart strategy with a degree of malleability indicating rapid transformation.
- Smart projects reliant on multiple stakeholder engagement demonstrating little applicable progress.
- Strategy incorporating community demonstrating success in civic engagement.

Aims	• Solve problems (Bacchi, 2010) • Present and evaluate research from current situations • Create recommendations for future progress
Type of Data Collected	• Qualitative – citizen opinion and contribution • Quantitative – mapping, environmental assessments (Bacchi, 2010)
Government Involvement	• Collaborations between government, non-governmental organisations and specialists (Srivastava and Thomson, 2009)
Positives	• Multidisciplinary approach (Arup, 2017) • Broad range of ideas • Proactive method • Makes positive difference to the built environment to 'shape a better world' (Arup, 2017)

Negatives	• Conflicting ideas could hinder progress (Srivastava and Thomson, 2009)

Figure 1: Table of Methodology

Case Study 1: New York Microgrid Project

Driving Factors

- High storm threat, 2012 Hurricane Sandy, causes a detrimental destruction to energy infrastructure, generating infrastructure vulnerabilities (Hales, 2015):
    - 8 million experience electrical failure (2012) 140 overline powerlines and transformers damaged
    - 28% increase in mortality (2005) Hurricane Sandy (Hales, 2015)
    - Half a million overhead power lines destroyed (Siemens, 2015)
    - 90mph winds

The increase in storm frequency due to climate change, has caused an improvement in resilience and risk management (Bird and Hoteling, 2016) and is essential in the mitigation of the current $9 million/year cost of unreliable power (NYSERDA, 2010). Priorities situate to 'make power grids more resilient to hurricanes' (Siemans, 2015). A microgrid (MG) is classified as a Level 2 smart city project (Arup, 2014), as a secure solution and a supply which is sought from a decentralised community based grid (Siemens, 2015).

Key Stakeholders

Development and initiation of an energy management system is integrated energy, market and distribution network which aims to improve the resilience of New York's energy grid. Energy storage will initiate a self-correcting MG which manages demand response (DR) (Frost and Sullivan, 2014). Regulations of operation and technology mitigate MG electrical isolation. Governing transformation is reliant on stakeholder input. A large contribution to MG strategy is from government collaboration:

- New York Public Service Commission (PSC),
- New York Energy Research and Development Authority (NYSERDA)
- New York Power Authority (NYPA)
- Long Island Power Authority (LIPA)

Project governance is headed by NYS Smart Grid Consortium, Reforming energy vision (REV). New York has a $40 million MG program underway. Multi-stakeholder aims include asset

ownership, diversification of monetization strategies, experienced operations (NYS Smart Grid, 2015) (Figure 2.). Stakeholders benefit from direct financial interest, owner benefit and enhanced customer connections (Morris et al, 2012). MGs increase resilience, customer ownership, economic performance and a decentralised grid. They are an important facilitator in real time management of distributed energy resource management (DERMS) and active network management (ANM) (NYS Smart Grid, 2015). Specific to disaster response MGs assist in returning the grid back to normal operating capacity; increase electricity availability as an emergency source, retaining functionality within the community if natural disaster strikes (Bird and Hoteling, 2016).

The New York State Smart Grid Consortium is a unique public-private partnership that promotes broad state wide implementation of a safe, secure and reliable smart grid; NYTOs, NYISO, IPPs, ESCOs.

Stakeholder	Aims	Input
Siemens	Large global MG stakeholder (Frost and Sullivan, 2014)	Roles are throughout electrical generation, storage, MG components, Distribution, smart meter instillation and operating upkeep
The New York State Energy Research and Development Authority (NYSERDA)	Work with stakeholders to develop the MG network	MG instillation; reduce energy costs, increase energy efficient, improve environmental performance, ensure system reliability (NYSERDA, 2010). $15.5 million available to fund energy storage projects to support the electric grid.
Consolidator Edison	Energy service company, providing efficient commodity supply within a competitive market	$66 million, expanding NYSERDA's existing CHP program, which has already supported the deployment of more than 140 CHP systems, all capable of community backup in case of a grid outage.
NYS Government	Responsible for the adoption of community utilities through smart grids	Investing $11 million to fund communities (Andorka, 2017), as an initiative to 'harden their power infrastructure' (Cuomo, 2017) in partnership with Green Bank.

Figure 2. Table of stakeholder involvement in the New York MG projects

Siemens and PJM, regional grid operator, are acting coordinators for the instillation of this integrated platform and potential technological lock-in. This rapid transformation for energy distribution aims to be complete by 2017, with progress in 2015 demonstrating 2 distribution networks.

Challenges for Utilities	Advantages for Utilities
Decrease in revenue	Form private/public partnerships
Demand reliability	Integrated network for renewable energy assisting environmental goals
Legislation limits planning and operations	Decentralised grid, deterring from centralised investment

Figure 3. Table indicating the challenges and advantages of public utilities as a stakeholder. Data sources from Frost and Sullivan, 2016.

The private sector plays an important role with support from government subsidies, although partnership with utility companies generates necessary financial, technical and government support (Fugure 4.).

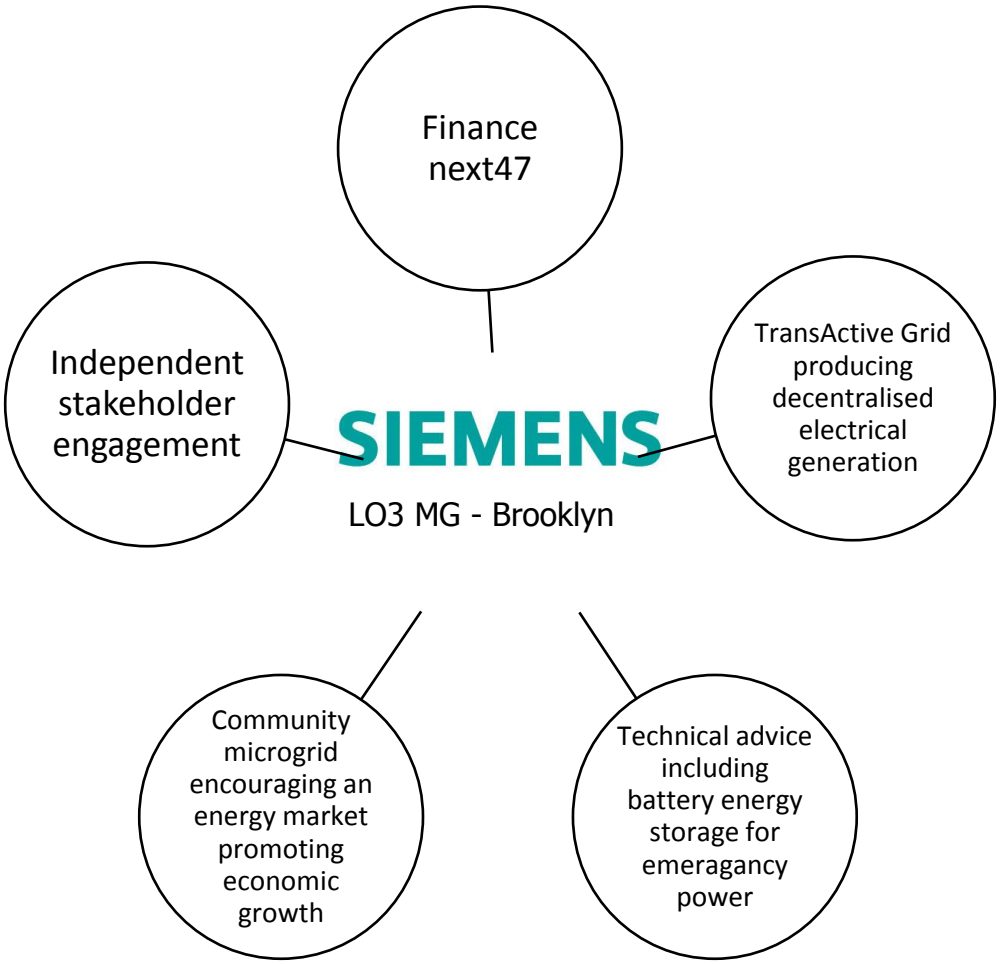
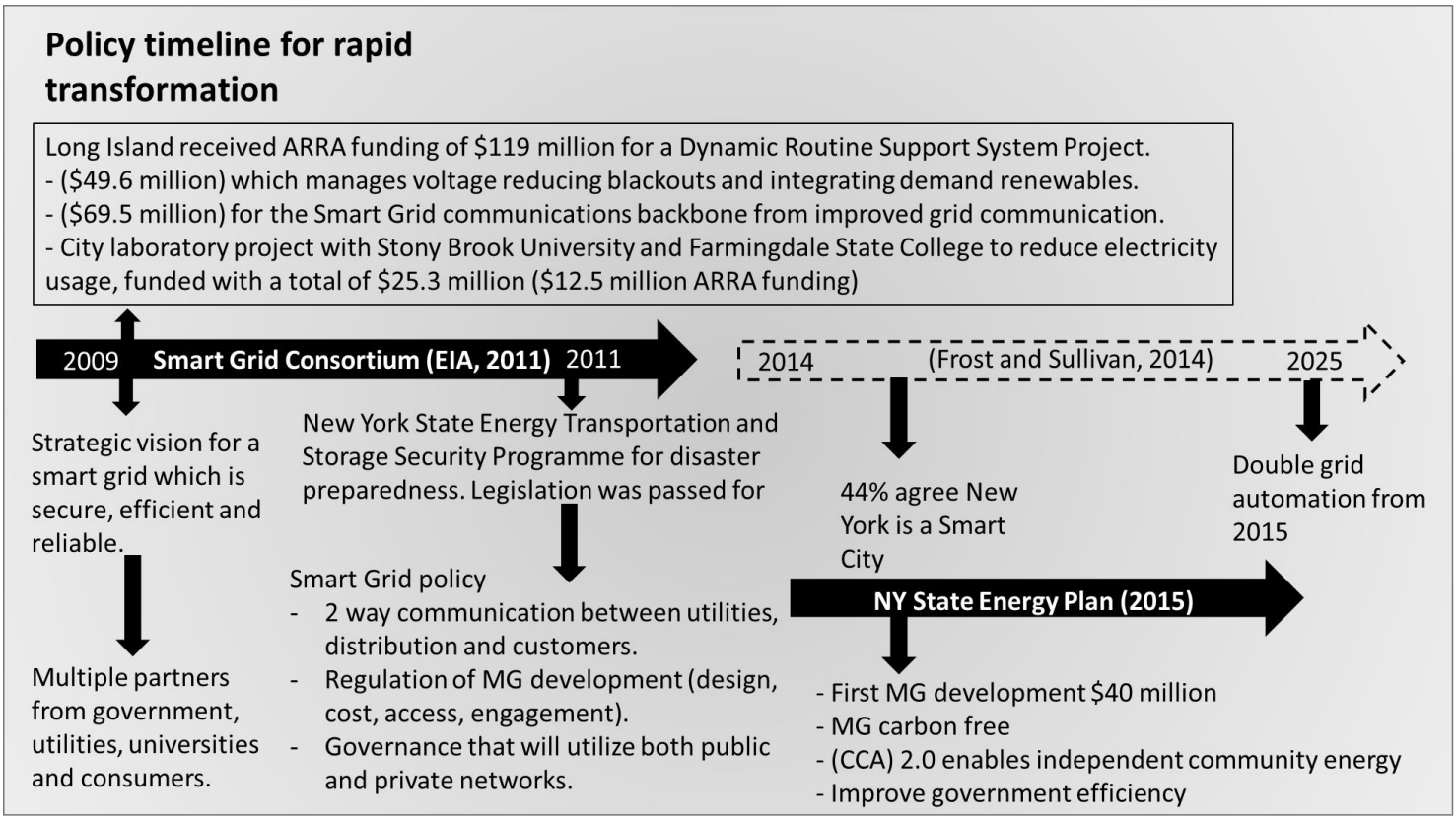


Figure 4. Stakeholder engagement map for LO3 Brooklyn MG, indicating the role of a private partnership

The neighbourhood wants to be prepared for the next hurricane (LO3 Energy). MG development offers a feasible solution to energy vulnerability, securing emergency supply, incorporating renewable energy use and reducing energy costs within the community.

Policy assessment of rapid transformation



New York State University aims to establish New York as a ULL for MG generation:

- Experimentation techniques (State University of New York Polytechnic Institute).
- Integrated renewable system which will act as a supporting feeder network, to the main power supply which is:
- Independent to the main grid, supplying a source (e.g. hospital or school).
- Important smart city solution to hazardous weather conditions, within New York, in creating a resilient power supply.
- Array of stakeholder engagement meeting targets for completion.
- Community preventative measure having city wide impact.

Figure 5. Timeline of policy transformation to MG instillation and future predictions for MG generated power. CCA – Community Choice Aggregation

Case Study 2: Christchurch 'SensingCity' project

Driving Factors

- 11 major earthquakes in the past century
- A destroyed city presented an opportunity to retrofit with smart technology

SensingCity is a non-for profit project which could be argued as a reactive measure to earthquake-prone regions and one which has been destroyed by previous disasters. The uniqueness of SensingCity, classified as a Level 3 smart city project (Arup, 2014), provides an open data stream encouraging civic engagement with city metabolism, through the sensing network. The SensingCity acts a ULL for smart innovation (2013) is a world first, real time project.

Project aims include CO^2 emission reduction, water quality improvement and the efficient infrastructure building. As the newest smart city concept, Christchurch is of particular interest with a 'front for future thinking' (Arup, 2014)

Key Stakeholders

Government collaboration between Auckland, Wellington and Christchurch has provided an important co-benefit innovative network to share smart strategy for technology, urban flows and earthquake strategy.

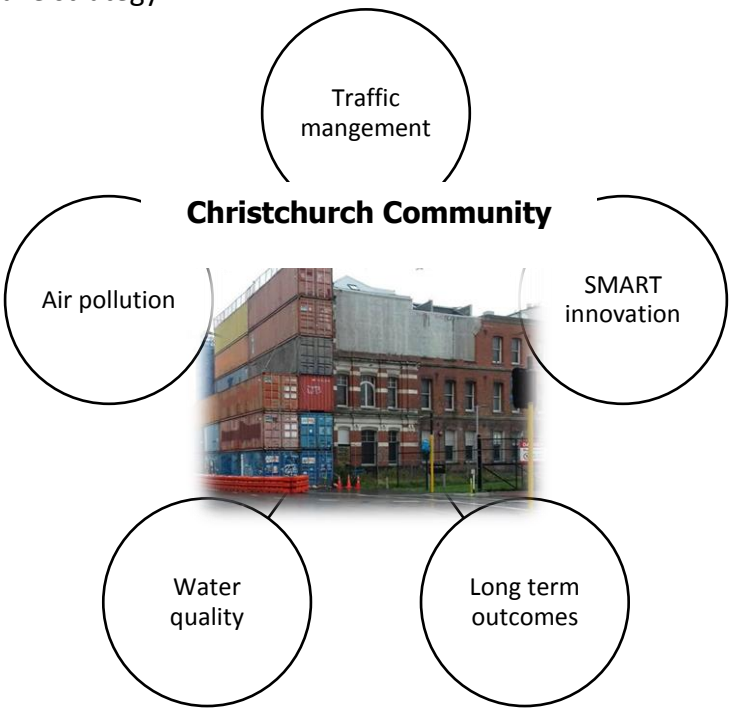


Figure 6. Christchurch community innovation outcome. Proposed ideas for the SensingCity project from the share an idea campaign (2011) produced 100,000 ideas on smart city concepts the community wanted to introduce. High citizen involvement is a key focus for SensingCity adoption (SensingCity, 2013), with 'hackathons' and engaging community. An extensive strategy was adopted including the Ngài Tahu community.

A multi- layer stakeholder engagement has provided funding and pioneering technology to develop Christchurch as a living laboratory with funding from the economic recovery programme (CERA).

Policy assessment of rapid transformation

Stakeholder	Aims	Input
Christchurch City Council	Integrated the Sensingcity network, through citizen engagement.	Provides open data for real time analysis of the sensing network. $330 000 to Sensingcity.
Massachusetts Institute of Technology	SMART city development through water quality sensing techniques. Engage local communities and companies in the stages of implementation.	'Little Water Sensor' (2013) pilot project for citizen smart phone engagement to report water quality.
UC UNIVERSITY OF CANTERBURY	SMART city development	'Living Laboratory' (Carr)
Land Information New Zealand Toitū te whenua	Environmental improvement throughout New Zealand.	$330,000 for the Sensingcity strategy, to introduce a smart city concept to Christchurch.
NZ TRANSPORT AGENCY	Improve traffic flow throughout Christchurch	Traffic sensors to navigate earthquake driven roadworks and congestion
Canterbury District Health Board Te Poari Hauora ō Waitaha	Provide real time data regarding environmental factors which could	Asthma sensors to provide real time data of air quality, improving the health of those who are sensitive to air pollution

Figure 7. Table of stakeholder engagement and the level of interaction throughout the project

Strategy	Aims
The Sustainable Energy Strategy	Smart grid is 10 years of development Introduction of smart meters to secure the energy supply, via a collaboration of 4 utilities, and reduce peak loads. Improve energy awareness, engaging citizens to reduce consumption and improve open data analysis
Core Vision Strategy	Climate change within the National Planning Policy Framework (NPPF)
Climate Smart Strategy	Climate change indicatives 2010 – 2025 Resilience to climate change processes to erosion, floods, droughts Reduce GHGs emissions An update from the Climate Change Policy 1995 including the local government act (2002) highlighting the significance of climate change as a role in critical decision making processes
Greater Christchurch Resilience plan:	Action7 which aims to further embed technology to collaborate public and commercial partnerships, importing the availability of resources. Real time control of resources Smart city plan with a 1-2-year commitment Sensing technology has an aim to improve citizen and government engagement, reducing costs and environmental impacts. Christchurch City Council have collaborated with LINZ to give this plan a 1-5-year commitment

Figure 8. Table of strategy for smart city integration and targets for future smart development

Arup, (2014) outlines:

- Thriving economy and provides high quality infrastructure.
- Inspiration to other cities as a viable strategy to generate an information market and capture sensing potential.
- Rapid implementation has been possible due to a great deal of community, public stakeholder and malleable institution engagement, empowering citizens with a drive for smart technology.

However, a criticism of this project lack of seismic sensor instillation and policy surround future earthquake mitigation. Although building surveys are not available through SensingCity, monitoring of earth movement will be and this will have direct links to emergency response operators, mitigating risk to citizen health in a cost effective and real time manner (SensingCity, 2013). As community engagement is reflected throughout all aspects of the smart city project, this is disregarded as a significant aspect. Moreover, SensingCity intends to be a pioneering ULL showcasing smart city technology applicable to other cities, therefore not appropriate for a sole focus on earthquake resilience.

SensingCity has established an exemplary model which is applicable to the Chicago Array of Things as a successful method of community and stakeholder engagement in smart technology implementation.

Case Study 3: Jakarta, Social Media Applications

Driving Factors

Jakarta is a megacity with over 10 million inhabitants (Thuzar, 2011).

- 1600s it has experienced seasonal flooding.
- Low-lying delta
- Poor quality yet heavily interdependent urban infrastructure which exacerbate occurrences (Holderness and Turpin, 2015).
- 72.7% of Jakarta is prone to frequent, heavy flooding
- Cost £1.9 billion in 2013 (Jakarta Globe, 2013; Holderness and Turpin, 2015).

This provoked a need to lessen flood impacts. Additionally, the present lack of understanding regarding urban interdependencies and integrated infrastructure within Jakarta means development of new and maintenance of current infrastructure is hindered.

By exploiting its extensive communication technology and social media usage to compile the data required to give authorities and local population maximum information during these events. Social media (mainly Twitter) and other information collection techniques in collaboration with technology the city enables the capture of vital data that can be used in disaster situations (i.e. during the floods) by creating in-depth real-time knowledge networks (Holderness and Turpin, 2015). This network can be used by local government and public services to protect infrastructure and population in an instant, effective and efficient manner.

Key Stakeholders

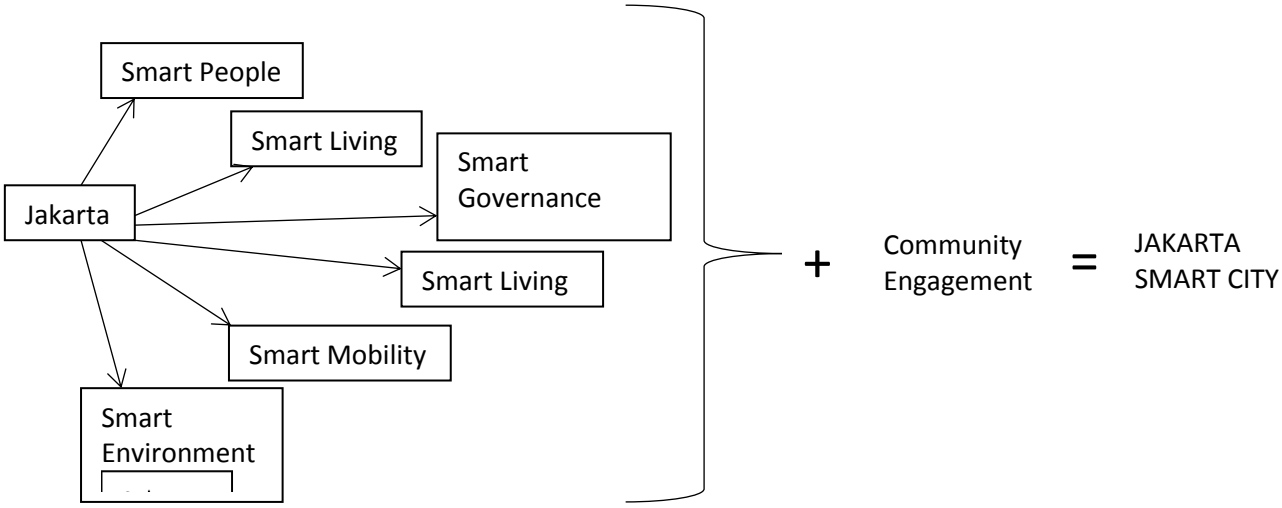


Figure 9. Jakarta's smart city idea is based on six areas (Jakarta Smart City, 2016).

Firstly, Jakarta Smart City Management Unit uses Google Maps, and Qlue and CROP Jakarta applications which enable, respectively, people to report incidents (e.g. floods) and officials to respond to these incidents instantly (Jakarta Post, 2014). They also provide real-time feeds from over 1000 CCTV cameras across the city. For flooding events specifically, PetaJakarta.org and CogniCity are projects, developed in partnership with the Jakarta government that collect and map citizen flood reports via Twitter. Initially, information is gathered regarding the flood itself: location, height, conditions; then evacuation requests and communication between citizens and the government emerge (Holderness and Turpin, 2015). Increased communication and governmental responses enables instant decisions to be made and the extent of flood damage to be mitigated.

Policy assessment for rapid transformation

- 2012, 2.4% of global tweets from Jakarta - one of the biggest Twitter groups worldwide (Holderness and Turpin, 2015).
- During monsoon season over 1000 reports of flooding were tweeted and collated by PetaJakarta.org and CogniCity.
- Over 97,000 website visits were made enabling the quick relaying of information to public services, resulting in real-time responses to disasters.

Unfortunately CogniCity was only a pilot study and so not yet fully developed or live (Open Data Institute, 2017). Due to lack of funding CogniCity is unable to develop its potential as a successful smart application. By gathering and sharing as much information as possible responses to floods and maintenance of infrastructure is enhanced and enables effectiveness and efficiency. This is so important for such a flood-prone city.

Case Study 3: Manchester future smart city

Strategy	Aims
Manchester 2025	- Smart city development, indicated through transport and infrastructure efficiency - Real time information - Zero carbon 2050 - Climate change action aiming for a 29% reduction in CO2 by 2020 - Include science and technology for a low carbon transition - Certain future strategy capitalising on investment for climate action planning (MACF, 2017) - Identification of the cause to climate change not mitigation of the impact
GM Framework	- Sustainable but beyond average in production and weak economic performance - Aims for knowledge of quality of the environment and economic success - Plans for infrastructure development - Aims to improve public access and green travel and development. Adapt to the UHI effect - Collaboration of the major and infrastructure companies, employ an infrastructure pooling strategy for multiple ownerships, SUDs and a cooperative working environment creating demand.
MCCA Strategy 2017 - 2050	- CO2 reduction - Adaption and resilience to climate change - Low carbon economy with city stakeholders - Zero carbon and climate resilient growth - No reduction in the green belt

Figure 10. Table indicating the proposed future strategy for GM resilience to climate change. Process of new governance, highlights the GI in Manchester must be enhanced (GM Framework).

Global urbanisation and development is accelerating at an exponential rate facilitating a consciousness for sustainable development. In Greater Manchester, Vision 2050, part of Foresight Future of Cities project. incorporates ideas of zero carbon, zero waste and climate resilience for the future resilience of the city.

Referring to Figure 10. Comparisons linking land categories suggested by throughout the GM framework and the spatial location for these targeted areas. Smart GI innovation suggests an all-inclusive approach throughout GM (Figure 11.), however particular focus should be on the city centre featuring little GI currently. Arup (2014) would place the proposal as a level 4 project.

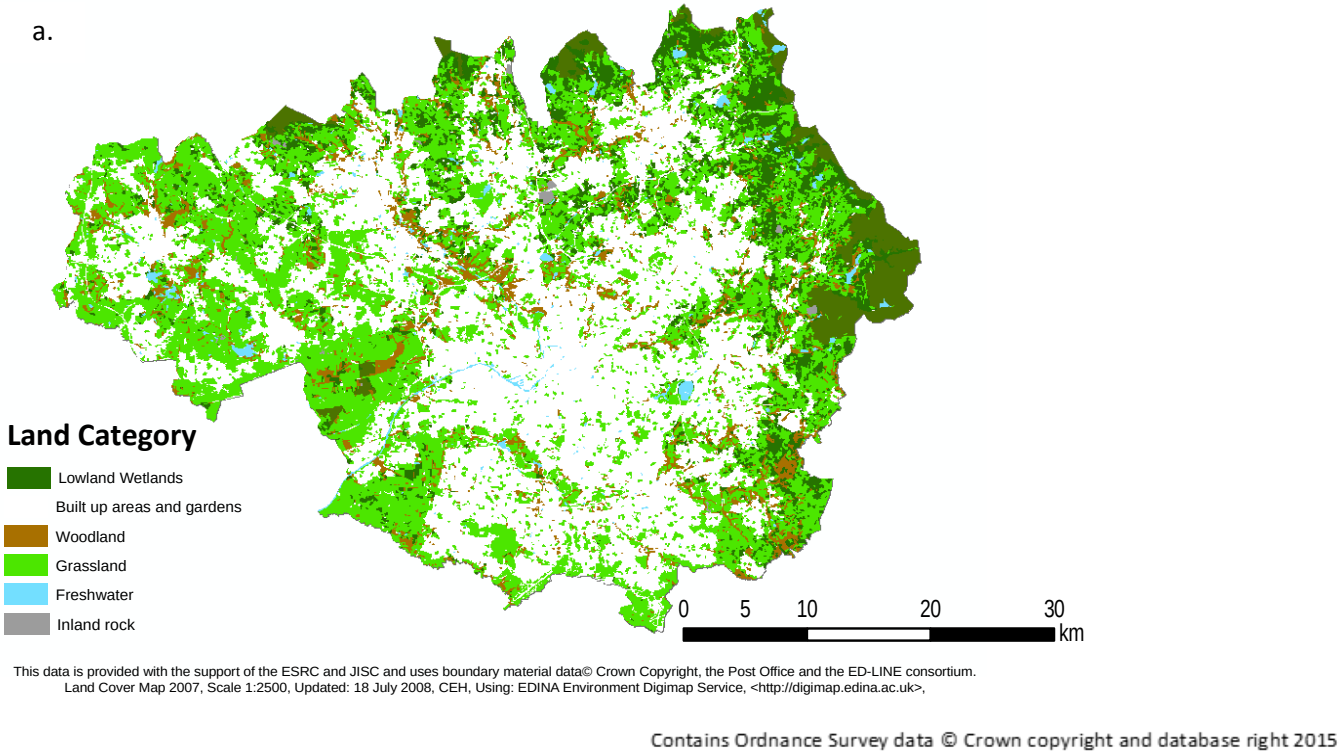


Figure 11.a GM land use map categorised according to the GM Framework. b. Map for smart city integration into the existing GM framework based on 11.a. for climate change resilience

Recommendations

The following statements reflect recommendations in governance for rapid smart city transformation

- Citizen engagement appears to indicate a successful method of smart city infrastructure implementation and engagement.
- Resilience to hazards which appear to have a daily threat are important to stakeholder engagement and are a key feature of strategy, rather than those threats from tectonic sources.
- The co-benefits from multiple organisations in smart city projects appear to limit the pace of transformation, which subsidies from public funding and citizen engagement enhance. A public-private partnership is important for the success of large scale projects but socio-technical innovation from institutions and government demonstrates more success for ULLs.
- Smart city market potential appears to favour exploring opportunities through private projects which have an integrated smart grid network, engaging multiple stakeholders and attracting interest fuelling technological lock in.
- Multi sectoral approach, for an integrated approach changes the socio-technical regime, measuring the level of obduracy. Rapid transformation is achieved through malleable governance and infrastructure, an increase in obduracy increase the stakeholders involved increasing the longevity at which smart city implementation occurs.

Conclusion

This report has explored different methods to achieve rapid smart transformation as an approach to improve city resilience to environmental hazards. Identified throughout is the benefit of subsides from governmental funding of projects and the multi-sectoral engagement this approach often includes. Socio-technical innovation is a key theme highlighted throughout a variety of project scales.

Economic driving factors appear to dictate the type of stakeholder engagement, with socio-technical innovation and decentralisation framing the greatest market potential. However, the governance of power flow is important to fuel niche concepts and mitigate the potential for technological lock in, promoting the socio-technical regime. Moreover multi-stakeholder engagement is important for the adoption of future smart grid concepts, incorporating advances algorithms, a challenge for global governance and stakeholder cooperation for change to city resilience to occur.

The proposed future for Manchester with complete smart grid integration indicates an extensive time scale due to the multiple stakeholders involved. In contrast, smaller projects in Christchurch and Jakarta illustrate the success of community engagement addressing institutions for evolution to social norms and increased city obduracy.

With recent predictions suggesting that the smart city market will have an estimated value of US$ 1.5 trillion by 2025 (NZTE, 2014) their importance is expected to become increasingly important to all those involved with urban planning.

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Appendix

Appendix 1. Arup (2014) Evaluation of scale for smart city project implementation and the actors involved in transformation

Smart City Project Implementation	 **Level 1**	 **Level 2**	 **Level 3**	 **Level 4**
Soft Infrastructure				
Value Assessment	Individual project business cases	Some non-financial value assessed	Holistic value assessment (social/environmental/financial)	Holistic value assessment supporting diversification of funding sources
Governance	Departmental governance structures	Some cross-departmental collaboration	Cross-departmental 'Smart City' management positions in place	City-wide governance structures and shared performance targets combined with international collaboration
Strategic ICT Focus	Limited ICT capability	Some strategic focus on ICT	ICT vision for the city	ICT vision and strategy overseen by dedicated City CIO
Citizen Engagement with Service Design	Limited citizen engagement	Project-level, basic needs analysis, pilots	Citizen feedback loops established	Citizen participation in integrated service design
Hard Infrastructure				
IT project focus	Little or no ICT projects	Targeted ICT project investments (e.g. Smart Grid)	Integrated ICT investments (including embedded sensing, control and actuation)	Real-time city operations optimisation
Integration of Data Streams	No data integration	Small scale data integration	Creative data mash ups pulling data to a common platform	Open data and crowd-sourcing initiatives
Digital Service Provision	Little or no digital service provision	Handful of digital services	Integrated digital services around the city environment	Diversity of cloud-based citizen services