UNEP

International Resource Panel

CITY-LEVEL DECOUPLING

Urban resource flows and the governance of infrastructure transitions

ANNEX: CASE STUDIES FROM SELECTED CITIES

UNITED NATIONS ENVIRONMENT PROGRAMME

In collaboration with UN Habitat

UN HABITAT

Acknowledgements

Lead authors: Mark Swilling, Blake Robinson, Simon Marvin and Mike Hodson.

Contributing authors: Adriana Allen, Ana Carolina Herrero, Anri Landman, Apiwat Ratanawaraha, Aromar Revi, Bernhard Truffer, Christian Binz, Claire Janisch, Damian Conway, Diana Daste, Edgar Pieterse, Gabriela Weber de Morais, Gye Woon Choi , Harriet Bulkeley, Ibidun Adelekan, Julio Dávila, Jyri Seppälä, Kulwant Singh, Lars Coenen, Lasse Peltonen, Lauren Tavener-Smith, Lian Guey LER, Maarten Hajer, Mari Tomita, Matthew Wood-Hill, Natalie Mayer, Oscar Ricardo Schmeiske, Perween Rahman, Sabine Barles, Shuaib Lwasa, Stefanie Swanepoel, Vanesa Castán Broto, Walter Alberto Pengue.

We would like to acknowledge the contributions of a wide range of people who in various ways have made it possible to publish this report. The first group that need to be acknowledged are the contributing authors who participated in workshops, contributed their writing and suggestions in ways that made it possible for this report to reflect the wide heterogeneity of contexts and urban experiences. As members of the Cities Working Group of the International Resource Panel, they have effectively acted as internal reviewers of this report as it has gone through its numerous iterations and revisions. We would also like to acknowledge the anonymous reviewers and the peer review coordinator, Dr. Lea Kauppi, for their valuable insights and contributions. There is no doubt that the overall quality and coherence of the report improved as we responded to the peer reviews that we received.

As far as funding for this report is concerned, while the bulk of the funding was provided by UNEP which we gratefully acknowledge, some of the work was also funded by UN Habitat for a related set of outputs. We are grateful for the cooperation on urban issues that exists between these two UN agencies which is also reflected in the two prefaces by their respective Directors. Furthermore, the institutional support of Stellenbosch University and the Sustainability Institute is acknowledged, as is the support of the South African Government's National Research Foundation that funds much of the background research conducted by Professor Mark Swilling and his team of researchers and postgraduate students. The ongoing support of the South African Government's Department of Environmental Affairs is also acknowledged.

Finally, we would like to acknowledge the valuable support of the Co-Chairs of the International Resource Panel and the various members of the Secretariat of the International Resource Panel who have supported the co-lead authors since the start of this project at a meeting of the International Resource Panel in Stellenbosch in November 2010, namely Janet Salem, Shaoyi Li and Lowri Rees.

Design/layout: GRID-Arendal
Printed by: Birkeland Trykkeri AS, Norway
Cover photos ©: Shutterstock

Disclaimer

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the United Nations Environment Programme concerning the legal status of any country, territory, city or area or of its authorities, or concerning delimitation of its frontiers or boundaries. Moreover, the views expressed do not necessarily represent the decision or the stated policy of the United Nations Environment Programme, nor does citing of trade names or commercial processes constitute endorsement.

The annex of the report should be referenced as follows:
UNEP (2013) *City-Level Decoupling: Urban resource flows and the governance of infrastructure transitions*. Case Studies from selected cities. A Report of the Working Group on Cities of the International Resource Panel. Swilling M., Robinson B., Marvin S. and Hodson M.

ISBN: 978-92-807-3298-6

CITY-LEVEL DECOUPLING:

Urban resource flows and the governance of infrastructure transitions

ANNEX: CASE STUDIES FROM SELECTED CITIES

UNEP

International Resource Panel

Compiled for the Cities Working Group International Resource Panel

By: Mark Swilling (Stellenbosch University, SA), Blake Robinson (Stellenbosch University, SA), Simon Marvin (University of Durham, UK) and Mike Hodson (University of Salford, UK)

With contributions from: Adriana Allen (Development Planning Unit, University College London, London, United Kingdom); Ana Carolina Herrero (Universidad Nacional de General Sarmiento and Instituto Nacional de Tecnologia Agropecuaria, Buenos Aires, Argentina); Anri Landman (Siyakhana Initiative for Ecological Health and Food Security, Johannesburg, South Africa); Apiwat Ratanawaraha (Department of Urban and Regional Planning, Chulalongkorn University, Bangkok, Thailand); Aromar Revi (Indian Institute of Human Settlements, Bangalore, India); Bernhard Truffer (Eawag: Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland); Christian Binz (Eawag: Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland); Claire Janisch (Biomimicry South Africa, Natal Midlands, South Africa); Damian Conway (Sustainability Institute, Stellenbosch, South Africa); Diana Daste (Development Planning Unit, University College London, London, United Kingdom); Edgar Pieterse (African Centre for Cities, University of Cape Town, Cape Town, South Africa); Gabriela Weber de Morais (Itaú Unibanco Bank, Sao Paulo, Brazil); Gye Woon Choi (University of Incheon, Incheon, Republic of Korea); Harriet Bulkeley (Department of Geography, Durham University, Newcastle, United Kingdom); Ibidun Adelekan (University of Ibadan, Ibadan, Nigeria); Julio Dávila (Development Planning Unit, University College London, London, United Kingdom); Jyri Seppälä (Finnish Environment Institute, Helsinki, Finland); Kulwant Singh (UN-Habitat, Nairobi, Kenya); Lars Coenen (Lund University, Lund, Sweden) ; Lasse Peltonen (Finnish Environment Institute, Helsinki, Finland); Lauren Tavener-Smith (Sustainability Institute, Stellenbosch, South Africa); Lian Guey LER (International Centre for Urban Water Hydroinformatics Research & Innovation, University of Incheon, Incheon, Republic of Korea); Maarten Hajer (Netherlands Environmental Assessment Agency, Amsterdam, The Netherlands); Mari Tomita (Ministry of the Environment, Kyushu, Japan); Matthew Wood-Hill (Development Planning Unit, University College London, London, United Kingdom); Natalie Mayer (Sustainability Institute, Stellenbosch, South Africa); Oscar Ricardo Schmeiske (Instituto de Pesquisa e Planejamento Urbano de Curitiba, Curitiba, Brazil); Perween Rahman (Orangi Pilot Project's Research and Training Institute, Karachi, Pakistan); Sabine Barles (Institute for Urban Planning, University Paris-Est Marne-la-Vallee, Paris, France); Shuaib Lwasa (School of Forestry, Environmental and Geographical Sciences, Makerere University, Kampala, Uganda); Stefanie Swanepoel (Sustainability Institute, Stellenbosch, South Africa); Vanesa Castán Broto (Development Planning Unit, University College London, London, United Kingdom); Walter Alberto Pengue (Peri-urban Institute, Universidad Nacional de General Sarmiento, Buenos Aires, Argentina).

Annex
Case studies from selected cities

These cases were selected to showcase innovative and visionary approaches to sustainable infrastructure change across a broad range of contexts, and are intended to demonstrate the abundance of options available that could inspire leaders of other cities to embrace creative solutions. While the approaches may be unique to each case, they can be used to inspire new thinking about infrastructural solutions that leverage existing strengths and resources to address social and environmental needs in an innovative manner. It is important to note that many of these cases have not been fully documented or are based on independently verified information. Nevertheless, they are concrete expressions of widely circulated ideas that have begun to be put in practice, with lessons that loop back into networks that can stimulate the creativity of the next generation of innovators, who could benefit from mastering the tools of material flow analysis.

Table of Contents

Abbreviations and acronyms

BRT	Bus Rapid Transit
CDM	Clean Development Mechanism
EU	European Union
EDAP	Energy Descent Action Plans
GDP	Gross Domestic Product
GHG	Greenhouse Gas
LED	Light-Emitting Diode
NGOs	Non-Governmental Organisations
WWF	World Wildlife Fund

Units

kg	Kilograms
kW	Kilowatt
kWh	Kilowatt-hour
MW	Megawatt

1. Sustainability through human unity in Auroville, India

By Anri Landman

Auroville is often referred to as a collective experiment dedicated to human unity, and can be viewed as a sustainable city-in-the-making. It was founded in February 1968 by Mirra Alfassa (1878–1973) - commonly known as 'The Mother - on the Coromandel Coast in Tamil Nadu state, India. Auroville was envisaged to be a continuation of The Mother's efforts to materialise the teachings of her spiritual collaborator, the Indian poet and philosopher Sri Aurobindo.[1] It is a working example of Sri Aurobindo's philosophy[2] that views cities as reflecting mirrors of the collective aspiration of the societies living within them.[3] The name Auroville stems from Aurobindo, but also means 'city of dawn'.

Organised around a common vision to promote human unity as opposed to sustainability per se, the material form of Auroville was not preconceived in specific detail. The Mother provided simple sketches, a Charter and guiding principles to direct actions towards human unity, but was clear that "the material conditions [would] be worked out as the realisation proceed[ed]."[4] The Charter[5] outlines that Auroville belongs to humanity as a whole; to live there requires serving the Divine Consciousness; it is a place of unending education, progress and youth, bridging the past and the future; and it is a site of material and spiritual searches towards actual human unity.

With support from the Indian government, land near the town of Pondicherry was allocated to the project. UNESCO has supported the city since its inauguration and reiterated its support at four UNESCO General Conferences.[6] Financial support came from pioneers, private individuals, European and American foundations, and since 1968, from Auroville International Centres.[7]

Roger Anger was the architect responsible for the city's original 'galaxy' design. Centered around the 'Matrimandir' building dedicated to silent meditation and completed in 2004, the city's four zones, residential, cultural, international and industrial, spiral outwards.[8] A green belt promoting diversity, environmental restoration and organic farming surrounds the circular city. The green belt is also a fertile zone for applied research in forestry, soil conservation, water management, waste management, and food production.[9] The entire city design has a radius of 2.5 km and spans 20 km^2. The Auroville Township Master Plan 2000 – 2025 contains the details of its design and has been endorsed by the Indian Government.[10] The end-goal is to build an environmentally friendly sustainable urban settlement with a population of 50,000, which simultaneously integrates and cares for an expanding rural neighbourhood.[11]

Prior to 1968, the 1011.7 h of forest that now shades the city was an eroded wasteland where little could grow.[12] Understanding that a mutually supporting relationship with nature was the most important starting point for a sustainable city, pioneers laid the foundations for the city and aligned human and environmental interests by planting trees. Today various settlements are organised around the function of forestry, including the propagation of indigenous flora, comprehensive contour bunding and the building of small check dams for soil and water conservation. More than two million forest, hedge, fruit and fuel wood trees have been planted since 1968,[13] helping to make the area more suitable for human habitation.

This founding regenerative approach has evolved as developmental programmes and facilities in settlements around the city have researched and implemented the most context-appropriate sustainable systems in Auroville's rural and urban areas. Auroville has its own recycling site that processes all but 14% of the total generated waste, and non-recyclable waste is currently stored until future solutions are found.[14] The city has 20 community-level sewage treatment facilities experimenting with the most effective ways of treating wastewater so that it can be safely discharged back into groundwater.[15] Renewable energy is generated by 1,200 photovoltaic panels, and water is circulated using 140 solar water-pumping units and 30 windmills. Some houses and small settlements rely completely on renewable energy sources.[16] Auroville has supported expertise in earth building,[17] and its Earth Institute develops and transfers cost- and energy effective earth-based building technology throughout India and to other countries through consultations, courses, seminars, workshops, its website, manuals and other documents.[18]

Aurovillians live in settlements of varying sizes and degrees of self-sustainability, separated by Tamil villages and temple lands in the forest that covers the city.[19] Each settlement contains one or more developmental programmes and facilities[20] that test and implement appropriate approaches to reforestation, organic agriculture, education, health care, village development, appropriate building technology and construction, information technology, small and medium scale factories and businesses, town planning, water table management, cultural activities, and community services.[21] Funding for specific projects comes from governments, government organisations and non-government organisations, both Indian and foreign, as well as international organisations.[22]

Some 2,221 Auroville residents, known as Aurovillians, were recorded in the census in June 2011. Of this population, 940 were Indian and the rest consisted of 44 nationalities.[23] The self-governing nature of decision-making processes in Auroville[24] that have shaped the city's policies, programmes and infrastructure are based on the principal of universal suffrage: every resident has the right to participate in decisions made at regular community meetings through open dialogue and by consensus rather than voting. Careful deliberation during these meetings has meant that progress is slow, but it has also ensured that the city grows in accordance with its vision and the expressions of its inhabitants.

Auroville's spiritual foundation has led to it being labelled as a religious utopian experiment.[25] This approach has been blamed for some decisions that appear to be based on idealism rather than taking contextual constraints into account, for example the incorporation of water features in the face of water shortages or the inattention of the initial city plans to the 40,000 impoverished villagers living in clusters between Auroville settlements. In 1968, the plan was for a city for 50,000 people, yet 40 years later only two percent of this population has been established. Auroville is often criticised for its slow progress.

Despite the city's slow progress, its unifying vision and decision-making processes that are both people-orientated and transparent have allowed it to achieve a sustainable developmental path. This could be attributed to the fact that Aurovillians choose to be there and are committed to addressing the complexities related to development in order to reach a shared vision. Another contribution to the successful sustainable construction of Auroville is the various developmental programmes and

facilities around which settlements are organised to test, implement and record the contextualised sustainable technologies, processes and progress of Auroville's construction. Although processes could be hastened, it is the recognition of the importance of the visioning and creation process rather than a predetermined timeframe which has contributed to its considered developmental progression.

2. The rise of green gated communities in Bangalore, India[26]

By Vanesa Castán Broto (Development Planning Unit, University College London) and Prof. Harriet Bulkeley (Department of Geography, Durham University)

Bangalore is a rapidly growing city. Its strong industrial heritage, mostly around textiles, and its position as a commercial node in South India has constituted the basis for rapidly growing Information Technology and outsourcing industries. This has fostered the growth of a cosmopolitan and educated middle class, which has generated new demands for housing. These new demands have driven the proliferation of gated communities in the peripheral areas of the city. Most of these developments follow energy and resource intensive designs that use imported materials, often transported over great distances. The great demands for energy and water in these new developments, whose residents are in the top brackets of resource use per capita in the city, compromise the capacity of an already strained government to provide public services.

The governments in Bangalore, both the municipality and the government of the State of Karnataka, experiences difficulties in regulating the rapid urban growth in the periphery of the city while rationalizing its use of resources. Many in Bangalore believe that for the city to go through a radical transformation process towards lower carbon emissions and better use of resources, new models of sustainable housing are needed. Some argue that the private sector – which some describe as intrinsically innovative – has the capacity to deliver the innovation needed for such transition.

Biodiversity Conservation India Limited (BCIL) is one such company, whose members, according to their own website, were seduced by 'the idea' of providing sustainable ways of living to those who could afford them. In short, BCIL transformed the aspirations of a sector of the cultured middle class for sustainable (green) housing into a consumer product. They started by creating exclusive self-sufficient villas in the outskirts of Bangalore, and launched their first major initiative of a compound of 91 houses in 2003 called *Towards Zero Carbon Development* (T-Zed). Starting with the ambition of being as sustainable as was deemed possible, this new gated community was completed in 2007. After the successful commercial launch of T-Zed, BCIL has started new projects in other areas of the city that extend and learn from the experience of T-Zed.

Because water scarcity is one of the main resource-linked problems in Bangalore, BCIL focused on ensuring the self-sufficiency of the development by calculating the carrying capacity of the land in relation to the potential supply from a rainwater harvesting system. They also focused on utilizing recycled and locally sourced materials to reduce the embodied energy of the buildings. Design considerations, cooling systems and green roofs were introduced to reduce residents'

energy consumption. Residents were implicated in community activities from cultivating organic vegetables, to separating wastes and managing the community's bio-combustion plant. However, their lifestyles remained unquestioned for the most part. Houses were provided with luxurious features including communal facilities such as a swimming pool and a naturally-ventilated squash court, and individual facilities such as complex air conditioning systems for large homes. The project was developed like any other conventional development emerging during the boom, relying on initial capital deposited by prospective buyers and delivering first the more expensive stand-alone houses in the development to finance the rest of the development, which consists of apartments.

The project was made possible by the marketing of a niche for green housing by BCIL, and by the commitment of numerous professionals who often committed more time and resources to this project than they would have committed to a conventional one. Being a pilot project, T-Zed faced difficulties such as the negotiation of bureaucratic permits and land disputes. T-Zed also faced issues related to the introduction of bundled innovations, which created additional problems in other parts of the design. These included the practical limitations of the rainwater harvesting system to meet the compounds' demands, as well as organisational problems when sourcing construction professionals capable of dealing with locally sourced materials.

BCIL carried out an in-house evaluation to examine the performance of T-Zed in terms of carbon emissions reduction. Although their estimations rely on a series of assumptions, it is reasonable to assume that residents in T-Zed have lower emissions per capita than those in other new gated developments catering for the growing middle class in Bangalore. However, T-Zed does not question the lifestyles which fuel those emissions and which are common both inside and outside T-Zed. BCIL has not been able to compare the emissions per capita in T-Zed with those of the average resident in central Bangalore, where the demands for water, energy and space appear much smaller. Some local NGO representatives blame changing lifestyles and aspirations towards idealized suburban American models for the increased consumption of resources in new developments. These claims are often accompanied by a sense of nostalgia for old and less wasteful living practices, and the conviction that consuming more resources may not necessarily lead to a better quality of life.

T-Zed has served as inspiration for other private developers and high-end consumers in Bangalore. The experiment has fostered new green housing projects in three different ways. First, BCIL has become a successful company, and it is now replicating the experiment on a large scale in Bangalore and nearby Mysore. BCIL's success has inspired the emergence of new developers interested in the same commercial model of green housing. Second, T-Zed provided space for training a new class of professionals interested in sustainable housing who could both develop their dreams of better, greener houses, and demonstrate how to achieve these ideals in practice. These professionals have worked in the growing green housing industry, but many of them have also gone to work elsewhere in the construction industry, incorporating some of the thinking behind T-Zed in mainstream projects. Third, T-Zed has set a model of desirability for high-end consumers who are now demanding green as a value-added feature of their houses. These new demands will contribute to growing interest in green housing as a profitable area of investment.

However, by transforming green housing into a consumer product, it has become a luxury (and an aspiration for the higher classes), rather than serving as a model for the collective provision of services to broader sectors of the population in Bangalore. T-Zed is a model of self-sufficiency and isolation, in which higher earners do not see themselves as contributing to the development and improvement of the whole city. Some of the practical solutions applied in the development, such as the digging of a borehole to augment water supplies, encroach on common pool resources but give little back to adjacent communities. Overall, the model of urban development is not questioned, and the city continues to spread beyond its limits, placing additional strains on the city's resources and generating conflicts, especially about transport, water resources and land.

While BCIL managers claim that they would like to do many things differently if they were starting T-Zed again – most of these changes pertaining to technical and organizational issues – they also believe that the model of commercialization of green housing is a valid response to current trends in urban growth in Bangalore. They do not question the factors leading to these trends and thus do not offer alternative models of higher density, mixed-use, collective provision of services to allow sharing responsibilities for the sustainability of the city beyond their gated compounds.

3. Masdar, Abu Dhabi: a zero-carbon city in the Arabian desert[27]

By Prof.Simon Marvin (Durham Energy Institute, Durham University) and Mike Hodson (The Centre for Sustainable Urban and Regional Futures, University of Salford)

Masdar (Arabic: مصدر, maṣdar, literally 'source') is an ambitious eco-city project currently under construction 17 km south-east of Abu Dhabi in the United Arab Emirates. At its core is a planned city constructed from scratch by the Abu Dhabi Future Energy Company with the majority of the start-up capital provided by the government of Abu Dhabi. Designed by Foster & Partners, it is intended that the city will be powered by solar energy and other renewable energy sources, with a sustainable, zero-carbon, zero-waste ecology.

The initiative is being driven by the UAE's poor ecological performance record, new economic pressures on the current oil and gas-based energy system, and a strategic aspiration to develop a transition to alternative and renewable forms of energy. Taken together, these drivers have led to the construction of an emblematic urban solution for the Middle East that is a key part of a wider energy transition that may have relevance in other contexts with energy-related challenges. The plan is that Masdar will gain early-mover status and support Abu Dhabi's transition from technology 'consumer' to technology 'producer'.

The UAE has one of the largest ecological footprints – and also the seventh highest oil reserves and sixth highest gas reserves - in the world. Reducing dependence on fossil fuels is a key element of Abu Dhabi's energy and sustainability strategy. Despite vast reserves of fossil fuels leaders recognize that these are finite and, combined with a desire to reduce carbon emissions, a new strategy for developing renewable energy could provide an alternative environmental future.

Yet there is also a strong economic rationale as the Abu Dhabi government wishes to maximise lucrative gas exports by reducing the amount of gas consumed internally for electricity through substitution by solar power. Abu Dhabi has lots of land, so has space for large-scale solar plants (both photovoltaics and concentrated solar power). This renewably-generated electricity will go some way towards helping the Emirate achieve its target of 7% of primary energy production derived from renewables by 2020.

The Masdar project is headed by the Abu Dhabi Future Energy Company (ADFEC). Initiated in 2006, the project was projected to cost US$22 billion and take some eight years to build, with the first phase scheduled to be completed and habitable in 2009. However, due to the impact of the financial crisis, Phase 1 of the city - the initial 1,000,000 m² - is now planned to be completed in 2015. Final completion is scheduled to occur between 2020 and 2025. The estimated cost of the city has also declined by 10 to 15 percent, putting the development between US$18.7 billion and US$19.8 billion.

Masdar City will be the latest of a small number of highly-planned, specialized, research and technology-intensive municipalities that incorporate a living environment, similar to Novosibirsk, Russia or Tsukuba Science City, Japan. The city is planned to cover 6 km² and will be home to 45,000 to 50,000 people and 1,500 businesses, primarily commercial and manufacturing facilities specialising in environmentally friendly products, and more than 60,000 workers are expected to commute to the city daily. Although city leaders have ambitious plans, so far only the Masdar Institute headquarters and campus – the flagship project for Phase 1 of the city - is currently under development.

The development aims to create a low-energy environment that works in accordance with the prevailing wind and sun conditions. Streets are narrow and designed to be shaded by buildings which are themselves angled to funnel winds through the city. No windows are positioned flat on to direct sunlight, but the majority of buildings will be covered with solar panels.

Later phases of the master plan will see Masdar becoming an entirely carbon neutral city, powered by renewable energy and equipped with an electric transportation system. Masdar will employ a variety of renewable power resources. Among the first construction projects will be a 40 to 60 MW solar power plant, built by the German firm Conergy, which will supply power for all other construction activity. This will later be followed by a larger facility, and additional solar panels will be placed on rooftops to provide solar energy totalling 130 MW. Wind farms capable of producing up to 20 MW will be established beyond the city's perimeter, and the use of geothermal energy is being investigated. In addition, Masdar plans to host one of the world's largest hydrogen power plants.

A solar-powered desalination plant will be used to provide the city's water needs, estimated to be 60% lower than in similarly-sized communities. Approximately 80% of the water used will be recycled and waste water will be reused as many times as possible, with greywater being used for crop irrigation and other purposes. The city will also attempt to reduce waste to zero. Biological waste will be used to create nutrient-rich soil and fertiliser, and some may also be utilised through waste incineration as an additional power source. Industrial waste, such as plastics and metals, will be recycled or put to other uses.

The project is supported by the global conservation charity World Wide Fund for Nature and the sustainability group BioRegional. In response to the project's commitment to zero carbon, zero waste and other environmentally friendly goals, WWF and BioRegional have endorsed Masdar City as an official 'One Planet Living' community. It will host the headquarters of the International Renewable Energy Agency (IRENA), and will act as a place of experimentation with researchers and engineers from the Masdar Institute regularly analyzing its performance.

Despite lofty intentions, many commentators have questioned whether Masdar will be able to be the world's first carbon-neutral city. Critics are concerned that the city will be only symbolic for Abu Dhabi, and that it may become just a luxury development for the wealthy. For example, the New York *Times* called it the ultimate gated community, "...the crystallization of another global phenomenon: the growing division of the world into refined, high-end enclaves and vast formless ghettos where issues like sustainability have little immediate relevance...."[28] Even if Masdar becomes a premium eco-development, its impact on the carbon intensity of mainstream development is likely to be limited. It remains to be seen whether the ambitious targets that have been set can be realised.

On the positive side, Masdar is an example of how large-scale investment can be secured to support a long-term vision for a new sustainable city. Engagement with the renewable energy industry has given credibility to its energy ambitions, and the development has systematically staked its claim on a number of technology opportunities from solar to bio energy during the planning stages. Although the financial crisis has been an obstacle, the project has moved forward by focusing on its role as a research and development location and test bed, thus allowing it to remain relevant and maintain its unique focus despite having to postpone the development of some areas.

4. Songdo, Republic of Korea - A New International Eco-City[29]

By Dr .Kulwant Singh (Advisor, UN-Habitat), Prof.GyeWoon Choi (Dean of University Development, University of Incheon) and Lian Guey LER (Researcher at International Centre for Urban Water Hydroinformatics Research & Innovation, University of Incheon)

Songdo International Business District (IBD) is a free trade and international business hub currently under construction on 6.1 km^2 of land reclaimed from the Yellow Sea, near Incheon International Airport in Republic of Korea. Developed by Gale International and Korea's POSCO E&C, this master-planned aerotropolis is a model of city-scale sustainable development that is only 3 ½ hours flying time from a third of the world's population. With the completion of the new 15 km suspension bridge in 2009, Incheon International Airport is just a 20 minute drive from the eco-city, making Songdo well-positioned to become an economic hub for Northeast Asia.

Designed by Kohn Pedersen Fox, the 9.2 million m^2 master plan includes commercial office space, residences, retail shops, hotels as well as civic and cultural facilities. When fully developed in 2015, the city will house 80,000 apartments, 4,600,000 m^2 of office space and 930,000 m^2 of retail space.

The delicate balance between maximizing energy efficiency and sustainable design versus project development costs is an area that has received much attention during design and construction of Songdo. Project funding consists of US$35 billion borrowed by Gale International from the domestic South Korean financial market, and US$100 million of Gale's own funds. More than US$10 billion has been invested thus far, and approximately 100 buildings have been completed or are currently under construction.

Songdo skyline viewed from the golf course

Songdo will set new standards in high-tech, green urban development. The following aspects of sustainability have been incorporated into the design of the city:

Energy

- Of Songdo's design goals, energy efficiency is the most significant. Energy efficiency strategies implemented in the building's design phase have a significant impact on carbon emissions and energy consumption during the operational lifetime of a building.
- Homes and offices use the latest materials and green technology, including water-cooled air-conditioning, solar panels, glazing that maximises natural light and retains heat in winter, and external and internal shading devices to reduce the need for mechanical air cooling.
- All homes and offices have master switches to turn off air conditioning, heating and non-essential electrical appliances when they are unoccupied. Computers are being built into the houses, streets and offices as part of a wide area network.
- Electricity use is expected to be 14% less than a typical city of the same size.

Water

- All water is recycled and re-used for washing, cooling or irrigation.
- Overall, buildings in Songdo should use 20% less water than conventional buildings found in cities of the same size.
- Many of the plants used in Songdo IBD are native/adapted species, helping to significantly decrease water demand for irrigation.
- Reclaimed rainwater from cisterns and treated water from the district grey water plant is used to reduce demand for potable water in the city's green spaces.

Transport

- Songdo is planned so that key functions — transport, shops, green space, culture — are no more than 12.5 minutes on foot from each other. Studies show that this is the maximum most people are willing to walk.
- Priority cycleways will discourage car use for journeys between 12 and 30 minutes — which covers most of Songdo. For everything else, there is a pool of cars for hire in underground car parks.
- To avoid the smog associated with many Asian cities, electric cars and bicycles have right of way and priority parking.
- Hydrogen powered green buses will soon ply the streets.

Waste management

- Standards for recycling and waste collection set by the municipality and national government will be applied. Within Songdo IBD, recycling will be heavily promoted through the provision of proper receptacles and/or sorting activities within each building.
- In addition to the more traditional collection of glass, metal cans, cardboard, paper, and plastic, areas will be created for recycling of light bulbs, batteries, and other materials.

Green building operations

- A 'green housekeeping' plan exists for use by building operators and promotes the use of low-toxicity or non-toxic products within buildings.
- Building occupants are educated via signage and targeted programmes about maximizing the effectiveness of the green attributes of the buildings.

Green spaces

- Some 40% of Songdo's area is parkland and waterways, making it the greenest new city in Asia. 240 ha of open space, including a 40 ha Central Park provide beautiful places of refuge and relaxation for the city's occupants.

- To save on fresh water, sea water is pumped to a treatment plant to be processed in accordance with government standards to fill the city's canals and water ways.

- Green buffer areas alongside sea walls have been designated as non-developable green spaces to act as flood prevention measures capable of withstanding the anticipated impact of a 100-year storm surge.

Quality of life

- Coupled with high-density buildings, a world-class transit system, and extensive neighborhood amenities, the provision of green space is a fundamental pillar of the 'quality of life' concept that sets Songdo IBD apart from other developments. The confluence of complementary urban design strategies works in tandem to create a community and a city that consumes less water and energy.

- Songdo IBD's leadership in sustainable development has key quality-of-life attributes for both corporations and residents. Songdo will be the first Leadership in Energy and Environmental Design (LEED) certified district in Korea, and the largest project outside North America to be included in the LEED ND (Neighborhood Development) Pilot Program.

In the implementation of the project, New Songdo City introduced several new concepts that proved difficult to implement due to political and regulatory jurisdictions of the local and national governments in Korea, and the conflicts with authorities that resulted. The foreign developers faced difficulties in introducing new concepts to Korean officials and the Korean real estate industry, and market acceptance of new design strategies and systems has been slowed by the need for end users to understand, accept and be able to operate these innovations.

Songdo's location presented challenges in obtaining LEED materials. Green products, such as low-flow plumbing fixtures, green refrigerants, and recycled, rapidly renewable, and low volatile organic compund materials, are rare in the Korean market, and the area lacks natural resources for other conventional building materials. Nonetheless, the Songdo IBD project has created demand for sustainable materials in Korea that will hopefully lead to the local development of these products with positive benefits for future projects.

Songdo combines the principles of transit oriented development and new urbanism with the traditional Korean 'Dong' or neighborhood. Although the location had an influence on determining placement of neighborhoods, the underlying principles and the application of benchmarking tools (e.g. LEED and carbon footprinting) allow for the design to be replicated with some customization to cater to the different lifestyles and cultures of other contexts. The applicability of this model is, however, limited as Songdo contains no social housing for low-income groups and is not planned to meet the needs of the poor or address social inequalities.

5. A sustainable island community on San Fransisco's 'Treasure Island', California[30]

By Prof. Simon Marvin (Durham Energy Institute, Durham University) and Mike Hodson (The Centre for Sustainable Urban and Regional Futures, University of Salford)

Treasure Island is a former naval air base built on 160 ha of reclaimed land in San Francisco, USA. By 2020, it is intended to become one of the most sustainable communities in the U.S with 6,000 new apartments and businesses. Over 50 percent of the power will be from renewable resources, including solar electricity and solar water heaters; the street grid has been designed to maximise the exposure of rooftop photovoltaics to sunlight, and all the buildings would be within a 15 minute walk of a ferry terminal to San Francisco.

The development will take place on Treasure Island and the neighbouring Yerba Buena Island. Both were created in the 1930s from fill dredged from the bay for the Golden Gate International Exposition. Treasure Island housed a naval air base for many years, and this has left the groundwater and air contaminated with asbestos, plutonium, radium and other harmful substances. Following the closure of the air base in 1997, the island was opened to residential and other uses and was home to 2,500 people by 2010. The plans for Treasure Island entail population growth of more than 19,000 residents.

San Francisco city leaders have high environmental expectations of what might be achieved through comprehensive redevelopment and expansion of the existing neighbourhood. As a former military base in a sensitive ecological region, the Treasure Island redevelopment must also contend with multiple stakeholders from wetland commissions to the Navy and housing agencies. In order to deal with the multiple challenges presented by the redevelopment of an already populated area, and existing environmental limits, and ecological expectations, the sustainable urban community concept aims for an integrated approach that includes multiple units of housing, an artificial wetland area integrated with water treatment, wind power, recreation and gardening areas, a marina, and a small shopping district. The developer hopes that Treasure Island will serve as a new model for sustainable communities in the United States.

In 2000, plans were announced to redevelop Treasure Island into a model sustainable residential area. Skidmore, Owning and Merrill (SOM) lead the design team for the development, supported by two local San Francisco firms, SMWM and CMG Landscape Architects. In the development phase in 2005-2006, ARUP was brought in to advise on transportation planning, site infrastructure and sustainability strategies. In 2006, a Sustainability Plan was prepared that outlined the long term vision for the Treasure Island/Yerba Buena Island (TI/YBI) Project covering ten key focus areas across the triple bottom line of sustainable development: environmental stewardship, community development, and economic vitality. Strategic goals, objectives, strategies, and potential partners were outlined, providing guidance for subsequent planning and design efforts.

The 2006 Sustainability Plan was groundbreaking in its scope and approach to sustainable development for large scale mixed-use projects, and provided an exemplary yet practical pathway to sustainability that many international projects have since followed. Rather than treating sustainability as a technical 'add on', the approach emphasizes the integration of sustainability into urban planning, form and social fabric. At the time, the project-tailored Treasure Island Green Building Specifications included in the 2006 Sustainability Plan were unique in terms of regulations for green building, and they represented a high bar for vertical developers to achieve. In 2008, the City of San Francisco codified many of the project's 2006 aspirations in its Green Building Ordinance (SF GBO), influencing the design of buildings elsewhere in the city.

In 2009, the TI/YBI Project was selected as one of 17 projects worldwide to participate in the Climate Positive Development Program led by the Clinton Climate Initiative. In this role, the TI/YBI Project will support San Fransisco's goal of climate neutrality and endeavour to set a global example in achieving large-scale urban development that is climate positive and cost effective. The comprehensive design has earned several awards including the American Institute of Architects National Honor Award and The Governor's Economic and Environmental Leadership Award.

On 8 June 2011, the San Francisco Board of Supervisors approved the development of a new neighborhood on Treasure Island between 2012 and 2022, with the first new residents occupying new sustainable towers as early as 2013. Since Treasure Island and Yerba Buena Island fall under the jurisdiction of the city and county of San Francisco, the project is collaboration between the San Francisco redevelopment board and a private development team.

The 2006 Sustainability Plan was updated in 2011 to reflect enhancements to the integrated approach, as well as how the TI/YBI Project will exceed green standards and ordinances in certain cases. For instance, strategies related to energy, water, waste, and materials have been grouped in the Integrated Sustainable Design Chapter to reflect the synergistic relationships between them. The Sustainability Plan also updates some of the 2006 targets to respond to changes in technology, local regulations, and additional commitments made by the Treasure Island Development Authority and Treasure Island Community Development, the project's Master Developer. Since 2006, California has adopted a new Green Building Standards Code and the City and County of San Francisco have adopted the previously mentioned SF GBO (2008 and 2010). Both of these regulations became effective in 2011 and the increased sustainability performance required under these new codes is incorporated into building designs.

The revisions between the 2006 and 2011 sustainability plan mean that many of the innovative features of the early plan have themselves been incorporated into new regulatory structures. Consequently the plan has had to work much harder to produce standards that exceed new environmental targets. Additionally the proposals received some resistance and quationing before they went to the San Francisco Board of Supervisors, who unanimously approved a planned US$1.5 billion green redevelopment plan for the island.

Environmental organizations such as the Sierra Club have raised concerns over the development, particularly relating to transport, climate vulnerability and affordable housing. Only one bus line connects to Treasure Island and The Bay Bridge, and the toll bridge that links the San Francisco peninsula with the East Bay is already a major bottleneck. The planned eco-village is centered on pedestrian and bicycle traffic but a sufficiently large population is required to justify regular bus and ferry services. Concerns were also raised about the number of parking spaces in the development, as well as a reduction in the number of affordable housing units from 2,400 to 2,000 due to a lack of funding. Other concerns are related to sea level rise in the case of climate change or a tsunami. Community advocates also worry that Treasure Island could end up falling prey to the environmental risks and drawn-out timelines of other area redevelopment projects like Mission Bay and Bayview.

In response to these concerns, the developers have promised new fill, higher sea walls, and dedicated bus and ferry lines. The board also approved amendments increasing the amount of affordable housing in the project, requiring that maintenance and landscaping workers be paid prevailing wages and that the developer consults with experts in any historic preservation projects. It also required that the development be evaluated after a few years to confirm that it is meeting goals for transit usage. In addition, the board approved a requirement that the developer pay a fine of up to US$10 million for development delays.

Although approval for the project has been granted, ground was only broken in 2012 so the lessons from the project are limited to the preparatory processes:

- The development and testing the sustainability proposals was lengthy, and during this time the project has played a role in shaping the regime within which it operates. Early proposals influenced the development of new environmental regulations adopted at state and local level, and this has meant that it has become more difficult to exceed these raised standards that now govern implementation.

- While such developments may be self-sufficient in terms of meeting their own infrastructural needs, it will rely on a broader infrastructural network to some degree. Careful attention needs to be paid to connections with surrounding infrastructure, such as public transport systems, if sustainable property developments are to integrate into their context in a sustainable way. In other words, without having to resort to private car use.

- The failure of similarly ambitious projects to make it from concept to implementation have influenced the terms and conditions under which the project is to take place. These include making some of the environmental standards binding, and requiring that compensation be paid in the event of delays in implementation.

The development of Treasure Island has required artful engagement with an existing context – of ecological problems, existing residents and stakeholders and the environmental expectations of policy makers and publics in San Francisco. This has made it more challenging than 'clean slate' eco-developments, but has provided interesting insights into the process through which existing regimes can be renegotiated rather than recreated from scratch.

6. Citizens contributing to urban sustainability in Vauban, Germany

By Gabriela Weber de Morais

The planning of Quartier Vauban began in 1993 when the City of Freiburg (approximately 221,000 inhabitants) bought an area of land accommodating a former army barracks from the German Federal Government to help address housing shortages. The original project included buildings with low energy standards, green spaces, dense urban design, public transport and a school. Additional goals like reducing car traffic and supporting co-building groups were included during the planning process, which involved the participation of citizens.

Following unsatisfactory results of the participation process in another district, results which only highlighted issues of interest to future residents rather than fundamentally changing the masterplan, the City of Freiburg went beyond legal requirements for participation in Vauban. Instead of just hearing from the future inhabitants through a consultation process, the City of Freiburg allowed them to play an integral role in the planning of Vauban by nominating Forum Vauban e.V., a non-profit organization established by local citizens, to organize the participation process in a professional way. From 1995 onwards Forum Vauban was recognized as the official organizing body for citizen participation in the project.[31]

Experts were called in to develop a set of measures to shape the concept of a 'Sustainable Model District', formulated by Forum Vauban, together with the city authorities and other partners, in line with ecological, social and cultural requirements. These aspects were discussed with citizens and then presented to city representatives, with special attention being paid to mobility and energy.[32] The forum also coordinated working groups and organized participation in individual projects such as the transformation of an old building into the neighbourhood centre. The EU LIFE programme and the German Federal Environmental Foundation supported the project with an investment of €42 million (approximately US$55 million[33]). LIFE contributed mainly to transport and mobility issues, while utility companies invested in the network infrastructures (including heating, water and energy) and public equipment was funded by the local and regional authorities.[34]

Vauban's development plan specified an energy consumption standard for heating of 65 kWh/m² per year for residential buildings.[35] This was developed in accordance with the Low-Energy Housing Construction standard adopted by the City of Freiburg in 1992 for contracts in which the City Council sold land.[36] Some developers however, have chosen to exceed this standard, constructing passive houses with energy requirements for heating of 15 kWh/m² per year or less. One emblematic project was the Solar Settlement consisting of 50 houses. These houses are referred to as 'plus energy' houses due to their high energy efficiency and use of large photovoltaic cells that generate more electricity than the residents consume. Their surplus energy of approximately 9,000 kWh/m² per year is fed into the public grid. Also, solar collectors were installed in several houses for room and water heating. Another important achievement was the construction of a district woodchip cogeneration plant (combined heat and power) supplying the buildings in Vauban with room and water heating through a local heating network, and electricity fed into the public grid.[37]

To reduce reliance on private cars, Vauban was designed to be a district of short distances. A combination of public transport (buses and a tram line completed in 2006), a car sharing scheme, and shortening distances between residential areas and local amenities.Two considerable incentives help reduce car use: the parking-free residential streets and the car-free living scheme. In the parking-free residential streets, cars are only allowed for the loading and unloading of goods and the speed limit is restricted to 30 km per hour. These regulations, originally planned for three residential streets, were extended to large parts of the second and third building sections of the district. Visitors can park on the main street or in the two garages on the outskirts of the district. Car owners living in the parking-free areas are expected to use the parking lots located in the district garages at a cost of approximately €20,000 (approximately US$26,000). If residents of the parking-free areas choose not to own a car, they sign a contract and become part of the car-free living scheme, paying a single fee of around €3,700 (approximately US$4,850). Regional legislation allows for the provision of car parking spaces to be separate from housing projects, but this is seldom implemented. Vauban's approach to traffic management is innovative in the scale at which the reduced car concept has been applied.[38]

The "solar ship" mixed use building in Vauban's solar settlement. (Source: author, Gabriela Weber de Morais, 2009)

To make housing more affordable, co-building groups were formed and four old army barracks were renovated by a group of future residents. Representatives of each co-building group met regularly under the coordination of Forum Vauban to discuss technical questions, and to support each other.[39] Many of the trees that have been preserved and the five green areas between residential streets were planned in community workshops.[40] A ditch system was designed to channel rainwater, allowing it to soak into the soil and regenerate ground water.[41] Organic and locally-grown food is also widely available for purchase in the weekly farmers' market and in the neighborhood co-operative organic food shop.

Certain aspects of Vauban's context have acted in favour of its sustainable development. As Freiburg is a university town, most of its residents are well-educated young families with knowledge of how to lobby effectively. They also seem to be more likely to embrace progressive ideas, as demonstrated by the 2009 elections for the German Federal Parliament in which 39% of the voters in Vauban supported the Green Party.[42] The city has a long history of support for public transport and was home to Germany's first citizen's movement against nuclear energy in the 1970s.[43] Furthermore, the region has plenty of forest resources, and Freiburg is the sunniest city in Germany, with 1,800 hours of sunshine per year.[44] The existence of environmental research institutes allowed residents to test environmental innovations relevant to this context.

One of the key elements of Vauban's success was the participation of future residents in the district planning, as well as in other collectively organized initiatives such as the co-building groups. Under the umbrella concept of a sustainable model district it was possible to test sustainability concepts in several areas. The average number of motor vehicles in Vauban is half the national average for Germany at 250 cars per 1,000 residents[45] and low energy housing adopting passive houses standards in 270 residences is estimated to reduce CO_2 emissions by 2,100 t per year.[46]

Certain challenges have limited Vauban's ability to optimise its sustainability. The obligatory connection to the electricity grid and its tariff structure has made some measures of reduction in energy demand unviable.[47] Likewise, in spite of affordable housing being available to the lower income population through the owner cooperatives and public subsities of rental units, an earlier plan to incorporate 25% of social housing into the district had to be reduced considerably because of cutbacks in the state housing program.[48] Residential streets could also work better if more enforcement from the Municipality discouraged free riders by fining illegally-parked cars.

Originally planned to be finished in 2006, Vauban was almost fully completed by 2008, and hosts a population of around 5,000 inhabitants and 500 jobs within its 38 hectare area.[49] Residents say that they enjoy living there due to lower noise levels and air pollution, safer streets for children to play, shorter distances that favour the elderly and greater interaction with neighbours when commuting on foot instead of by car.[50] These insights reinforce the idea that sustainable lifestyles are not only advantageous for the planet, but can be socially desirable too.

7. Closing the resource loop through Urban Agriculture in Accra, Ghana

By Matthew Wood-Hill (Development Planning Unit, University College London)

Against a background of water scarcity, urban farmers in Accra lacking access to clean piped water to irrigate their crops, or unable to afford to use the water available, have been turning to wastewater as a solution. Accra's expanding metropolitan population is putting greater demand on the water supply, leading authorities to declare it illegal to used piped water for irrigation without paying a surcharge. As a result, farmers and their forebears who in many cases have cultivated

their plots for over 50 years have been filtering water out of the waste stream. Adopting this practice has enabled them to maintain their livelihoods and their own sustenance, and to contribute to the greater food security of local communities and by implication the city itself. With clean water difficult to come by, wastewater has a vital enabling role in urban agriculture practice, which itself is the building-block for a value chain of related employment activities in the informal sector.

Using wastewater for crop irrigation has numerous potentials. Primarily it can provide a fundamental service for the city by reusing liquid effluent discharged by local districts. Removing liquid effluent from the waste stream contributes towards closing resource loops by turning outputs of the system into useful inputs, which contain a greater nutrient value than treated piped water. The Accra Metropolitan Assembly permits wastewater irrigation solely for root vegetables, frequently performed through furrow irrigation, ensuring that leafy vegetables and others that are traditionally eaten raw are not contaminated by the potentially harmful pathogens in the effluent water. The social and environmental value of urban agriculture to Accra is increasingly being realised, but the support from various actor groups has yet to be translated into a cohesive formal policy at the National or Metropolitan scales.

Chief among the groups recognising the potential for wastewater recycling through urban agriculture have been the International Water Management Institute and the Resource Centres on Urban Agriculture and Food Security. Together with several other key interested stakeholders, they form the Accra Working Group on Urban and Peri-Urban Agriculture (AWGUPA). This consists of 15 member-groups including NGOs, CSOs, the University of Ghana, farmers associations and, crucially, governmental departments of planning, the Ministry of Food and Agriculture, and the Accra Metropolitan Assembly. This relationship has fed into initiatives that attempt to train and educate farmers in the safe use of wastewater to reduce contamination, rather than criminalising the practice. Beyond this, AWGUPA has been working to enhance the legitimacy of farming groups in Accra and recognising the valuable service they provide the city through their use of liquid effluent. Though initially an 'unplanned' intervention, as farmers responded to limited access to clean water, wastewater-fed agriculture in Accra has brought these stakeholders together and now more vigorous calls are being made to enhance the legitimacy of farming groups in the city by recognising the potential of the contribution they make towards more sustainable resource management through the reuse of liquid effluent.

Key obstacles to the institutionalisation and gradual scaling-up of the practice include the threats posed by buildings encroaching on farmland, and by the non-committal attitudes of governmental authorities and the traditional council. Growing pressures on land in Accra resulting from continued urbanisation and housing shortfalls have resulted in many such encroachments, frequently on highly unsuitable land. This land, commonly appropriated by farmers, is held in trust by the State on behalf of the Traditional Councils. In spite of the illegitimacy of the act, members of the Traditional Councils can be easily tempted into selling off parts of the land for development. As a result, urban farmers have little or no land security, and consequentially lack livelihood security.

Farmers receive limited support in reacting to physical impediments such as the siltation of drainage channels relied upon for the delivery of wastewater – a situation further exacerbated

by poorly regulated municipal solid waste disposal. Furthermore, access to financial support is limited and the full backing of proponents of urban agriculture, such as AWGUPA, who recognise its ecological benefits, is restrained. This has made it difficult to transpose the principle of wastewater for irrigation from rhetoric into policy, albeit supported by practice.

The potential contribution of re-using effluent water to urban sustainability is significant, but has yet to be measured quantitatively. Wastewater use can lessen the demand for clean piped water by appropriating the liquid effluent for irrigation purposes, which can in turn reduce the intensity of chemical fertiliser usage. In transforming wastewater into a resource, the overall amount of discharge (or net throughput) in the city's drainage channels is decreased, reducing the amount of contaminated water that could potentially affect communities and individuals further downstream.

Broader benefits of urban agriculture include protecting food prices from increasing transport costs (fuel prices increased by 30% in January 2011[51]), reducing emissions from 'food miles' (that is, the distance food is transported from its production site to the consumer), and diversifying sources of agricultural produce to make the food economy more resilient. Composted organic waste materials can be used to enrich the soil and further reduce the demand for fossil fuel derived fertilisers, allowing for land that is generally unsuitable for developments to be put to productive use.

The Resource Centres on Urban Agriculture and Food Security estimates that approximately 1,000 farmers are engaged in urban agriculture in Accra, but absolute numbers are unknown given the informal nature of the activity. The reluctance of State and Traditional Authorities to institutionalise urban agricultural activities in Accra has made comprehensive evaluations

Encroachment on the banks of one the city's drainage channels. (Source: Fong Yee Chan, 2011)

impossible. This prevents a better understanding of urban agriculture's contribution towards more sustainable resource flows, and remains a barrier to the spread of the practice.

The practice of wastewater-fed agriculture in Accra has offered a possible solution to excess sewage water in the city, closing the resource loop by turning a waste product into a productive input, and potentially lessening the strain on sewage infrastructure in the city. Urban agriculture is a primary livelihood activity for many urban citizens, and a cornerstone of the local food economy. However, without consummate support from institutional bodies at the municipal and national level, urban farming in Accra is at risk from increasing land pressures posed by continued urbanisation. As a result there is little desire to pursue longer-term sustainable farming practices in many cases, with agricultural plots seen as transitional land awaiting further development. Crucial to the success and continuation of agricultural activities in Accra, is gaining institutional recognition of the valuable role the sites perform in the metabolism of the city, particularly through the recycling of wastewater. Recognising urban agriculture as a valid livelihood activity and supporting its development could enhance this role and the contribution of the practice to the sustainability of the city. Having already united the members of AWGUPA, the issue of wastewater reuse provides grounds for engaging new stakeholders around a common concern, and turning it to the benefit of the urban system.

8. Shifting urban development away from automobiles in Bangkok, Thailand

By Dr. Apiwat Ratanawaraha (Department of Urban and Regional Planning, Chulalongkorn University)

Since the 1980s, Bangkok has been infamous for its ever-worsening traffic congestion. As Thailand embarked on modern economic planning in 1961, Bangkok rapidly became a modernized and motorized city. The Thai government imported an American approach to urban planning, with an emphasis on automobile-oriented infrastructure as well as zoning-style land use controls. New urban development and transport projects were aimed at facilitating the efficient flow of people, goods and services in support of economic production. These projects led to a geographical separation of commercial, industrial and residential areas, reinforcing the spatial 'division of labour' and a physical separation between living and working locations. Since then, Bangkok's built-up area has extended along the main inter-urban roads beyond the traditional core areas. This has been driven by various factors, including the shortage of land for housing in the city, the construction of expressways linking suburban locations with the central business districts, and the lack of land-use controls, particularly restrictions on the locations of subdivision projects.

While road development was planned and generally financed by the government, housing development was led by the private sector. Housing projects followed the construction of roads, expanding the city's boundaries to the suburbs. These projects were implemented with little consideration for urban development implications, let alone environmental consequences. Even with the power to control land-use planning, urban planning agencies did not have authority over infrastructure development by other agencies, thereby leading to the proliferation of subdivision projects on green field sites.

To combat increasing traffic congestion, the government started to build more arterial roads, ring roads, and expressways. Since Bangkok's first expressway was built in 1981, more than 200 kilometres of elevated expressways have been built in the metropolitan area. More than 80% of the city's daily trips during the early 1990s were by bus, cars, motorcycles and taxis. Instead of decreasing congestion, the problem became even worse: average vehicle speeds during peak hours dropped to as low as 8 km/h.[52]

It took planners and policymakers many years to realize that traffic congestion did not improve with more roads and expressways. Alternative modes of transportation were desperately needed, and mass rail transit became an attractive option. To policymakers back then, the main objective of urban rail projects in Bangkok was to reduce traffic congestion, not necessarily to achieve urban sustainability. However, shifting commuters from private automobiles to rail transport significantly reduces the fossil fuel consumption and emissions associated with their mobility, making it a more environmentally friendly alternative.

Master plans for urban transit were repeatedly drafted, endorsed, scrapped, revisited, and endorsed again over the years before actual projects were implemented. The first project was supposed to be in operation by the early 1990s, but political and bureaucratic issues delayed and derailed the project. There were even civic demonstrations against the project due to concerns about pollution, crime, urban aesthetics, and accidents. It was not until 1999 that the first urban railway, the Bangkok Transit System (BTS), began service.

The introduction of the BTS was a turning point for Bangkok. Gradually people started to realize the benefits of mass transit, and the ridership for the BTS steadily increased. During the first few years of its operation the ridership was fewer than 150,000 trips per day, but it picked up quickly afterwards and the ridership as of September 2011 was about 500,000 trips per day. The figure was expected to increase by at least 15% in 2012.[53] The trend was further strengthened by the opening of the Bangkok Metro in 2004, the Airport Link in 2010, and two additional extensions of the BTS lines in 2009 and 2011. Four other transit lines are currently under construction. According to the current Bangkok Mass Transit Master Plan, a total of about 290 kilometres of mass rail transits will be built in Bangkok. Another ambitious plan expects the city to have almost 500 kilometres of urban rail by 2030. Even among transport planners, it is no longer fashionable to talk about expressways - mass rail transits are considered the way forward for Bangkok.

Despite the short timeframe since their introduction, urban rail systems have already had a noticeable impact on the spatial structure of the city, slowing both the pace and scale of suburbanization. While the core areas of Bangkok have always been vibrant, those areas with access to the transit stations have gained greater advantages than others. Owners of commercial buildings now find ways to connect with the train stations either via Skywalk (the second-level pedestrian way) or underground tunnels.

Many residential housing developers have substantially revamped their investment strategies from focusing on subdivision projects in the suburbs to condominium projects along the rail lines. According to the Government Housing Bank, only 26% of the new housing units completed in 2010 were in subdivision projects for detached houses in the suburban areas, while 42% were

Bangkok Subway (MRT) (Source: author, Apiwat Ratanawaraha 2011)

condominium projects in the inner areas of the city. Property developers used to promote their projects by stating how close they were to expressways; now they boast the proximity to transit stations.

The paradigms and underlying assumptions for urban planning and control in Bangkok have also changed. Before the BTS, all Bangkok Comprehensive Plans were based on the idea of an automobile-based city. The two recent Comprehensive Plans have focused more on transit-oriented development, providing additional incentives for development close to transit stations.

The obvious shift to rail-oriented development does not mean that Bangkok's streets are no longer congested. According to the Office of Transport and Traffic Policy and Planning, approximately 1500 cars and 1100 motorcycles are still added to the streets of Bangkok each day. Nonetheless, the transit systems provide people with modal options that they did not have before. They also create more options in terms of where to live, as an increasing number of urban redevelopment projects increase residential space in central areas of the city where jobs are concentrated.

The shift from automobile-dominant infrastructure development to a rail-based system can be attributed to several factors. Ironically, one factor is the level of congestion which became so bad that people were ready to embrace any reasonable alternatives to improve their commute. The benefits of a rail-based transportation system have also become apparent as fuel costs and energy concerns are on the rise, thereby providing an attractive alternative to private cars. Changes in population structure may also contribute partly to the shift. As young professionals delay marriage and have fewer children, they are willing to live in smaller condominium units in the city, instead of buying new houses in the suburbs and having to buy cars. The success of the BTS has made it a showcase that has helped to build support from the public and policymakers for building up the subsequent systems. Another reason for the increasing popularity of rail is that it has become extremely difficult and expensive for the state to expropriate land from private land owners to build expressways in the city. Several public demonstrations in the 1990s were successful in preventing construction of highway projects. Mass rail projects involve less land expropriation, making it an easier and attractive choice for policymakers. The shift in mindset of policy makers is critical, as it now seems that mass transits are more manageable, feasible and sustainable. It is no longer fashionable to argue for highways.

Although Bangkok's gradual shift to mass transit is a welcome phenomenon, considerable room remains to improve the sustainability of the city's public transport system. Mass rail transit remains 'class transit', as the fares are expensive compared to buses and only the middle class can afford to

use them. The benefits of mass transit in terms of addressing intra-generational equity are thus rather limited. With attention focused mainly on building mass transits, bus services have been neglected and service quality remains poor. Without improving the quality of other modes of public transportation, the potential contribution of mass rail transits to urban sustainability might not be fully realised.

9. Re-using water with on-site wastewater treatment in Beijing[i]

By Christian Binz, Bernhard Truffer and Lars Coenen

China's capital city, Beijing, has faced water shortages for many years due to a combination of diminishing supply and increasing demand. Successive years of below-average rainfall, high population growth and pollution of surface and ground water have resulted in per capita fresh water availability dropping from 1,000 m^3 to less than 230 m^3 between 1949 and 2007. As the city has expanded, demand has shifted from agricultural and industrial use toward residential use, with domestic water consumption more than doubling in the ten years leading up to 2005. Making matters worse, policies have diminished supply options by allowing for Beijing's watersheds to be degraded, and have supported wasteful water consumption by favouring large-scale engineering projects to increase water supply at little or no additional cost to consumers.[54]

In one of Beijing's earlier efforts to address water shortages, the local government introduced regulations in 1987 that required all hotels with a construction area exceeding 20,000 m^2 and all public buildings exceeding 30,000 m^2 (such as schools, universities, train stations and airports) to introduce on-site water treatment facilities to allow for water to be re-used. When well implemented and operated, decentralised water treatment systems can allow for the more efficient management of water resources, can reduce pollution of surface and groundwater systems, and can overcome many of the limitations of centralised waste water treatment plants. These smaller plants are quicker to plan and install, and are better able to cater for rapidly changing capacity requirements in fast-growing cities like Beijing. By re-using grey water and partially-treated wastewater on site for non-potable uses such as toilet flushing, irrigation or street cleaning, demand for potable water and centralised water treatment facilities can be reduced, which saves resources and costs.

At the time of the new regulations, Beijing had very little modern infrastructure in place to deal with its waste water, and lacked local expertise in centralised or on-site water treatment (OST). In order to comply with the regulations, hotel owners had little choice but to seek advice on planning and implementation from international companies - mainly from Japan, Germany and France. Until the mid-1990s, Beijing's demand for OST expertise and technologies was primarily met by these foreign companies. Their professionalism and economic profitability helped to build the legitimacy of OST in Beijing, and the positive experience of these technologies in the hotel industry inspired local entrepreneurs to capitalise on this new market segment.

i Unless otherwise cited, this case study draws on Binz, C., Truffer, B. & Coenen, L. 2012. Systemic anchoring of global innovation dynamics and new industry formation – The emergence of on-site water recycling in China. Paper presented at the 2012 GLOBELICS conference in Hangzhou, China.

In the early 1990s, academics from Beijing recognised OST as an interesting field of study. Pilot projects and other experiments with OST technologies were conducted at universities and research institutes, predominantly aimed at exploration of the new field rather than developing marketable products. One research group from Qinghua University later partnered with a transnational water company to become one of the world's leading centres of expertise on membrane bioreactor technologies – a core process for many OST systems.

To begin with, entrepreneurial experimentation in OST systems was largely inspired by imported technologies from Japan and Europe. Foreign companies struggled to acquire a dominant market share and many eventually left Beijing, deterred by corruption and a lack of clarity on the regulations. Toward the end of the 1990s, small Chinese companies started offering copies of imported products which were much cheaper but did not function as well.

Based on the positive results achieved in the hotel sector, Beijing's government decided to extend the OST regulations to new residential developments in 2003. Developers of new residential developments with a total floor surface in excess of 50,000 m^2 would need to install on-site water recycling facilities. At the time, Beijing was undergoing a construction boom, and this addition to the regulations opened a market niche which presented enormous opportunity to local businesses.

Demand for OST systems grew substantially, and many new local companies were founded to serve this market. In the first few years, these companies underwent a steep learning curve, finding out about and adapting to technical and organisational challenges. The growth of local knowledge was aided by interactions between business and academia, as new companies sought scientific knowledge from research institutions, which in turn learned from the practical experiences of local start-ups. With its international linkages, the academic community also helped to keep Beijing's OST industry up to date with the latest international developments in the field. Local actors started to move into the hotel market, gaining market share as international companies continued pulling out of Beijing.

Despite increasing enthusiasm about OST and the rapid development of new knowledge and technologies, it became evident within five years of the new regulations that their application in the residential sector had failed due to numerous institutional shortcomings. Inadequate regulation and a lack of law enforcement meant that the ongoing operation and maintenance of OST plants was inadequate, and many of the new systems failed within a few years. Beijing's water pricing structures also made it impossible to run residential OST plants profitably, further disincentivising the re-use of waste water. These institutional issues delegitimized the use of OST in the residential sector to such an extent that only an estimated 10-15% of the residential systems installed are still in operation. This demonstrates the importance of adapting institutions and regulations to support new technologies, and of pricing scarce resources appropriately to encourage their conservation.

In the last 5 years, Beijing's real estate market has slowed down and the OST expertise developed in the city has begun to be applied elsewhere. Despite poor penetration of water recycling technologies into the residential market, Beijing's OST community has recognised opportunity in national policies pushing for the build-up of infrastructure in peri-urban and rural areas. Since 2007, advocacy

coalitions for rural OST have gained increasing visibility, and many of the companies that were set up to serve the residential market have diversified to serve rural and industrial markets. Instead of being led by regulations, the actors in Beijing's OST market have sought new market niches in China and their water-saving technologies and knowledge has spread.

This case study shows how city regulations can stimulate the development of resource-saving infrastructure industries and sustainability oriented innovation, and how collaborations between businesses and academia help to anchor new infrastructure concepts like water recycling in contexts that are relatively unencumbered by outdated infrastructure approaches and their associated interest groups. Beijing was able to attract foreign knowledge, transfer it through entrepreneurial experimentation and retain the learning and built up capacity in support of a new industry. While some of the foreign companies who brought knowledge and expertise to the Beijing market may have been disadvantaged by operating in an environment where their intellectual property was not secure, the loose regulatory environment acted in favour of local entrepreneurs who were able to experiment with and adapt these technologies to the local context. The expertise that has been retained and built upon can now be sold to other areas that wish to invest in decentralised water treatment technologies, creating a new green economic sector for the city.

10. Durban's closed-loop landfill site at Mariannhill, South Africa

By Natalie Mayer

About 450 t of waste arrives daily at the Mariannhill Landfill Site, located 20 km from Durban. Far from an ecological hazard, this clean development mechanism project sets new standards for sustainable urban infrastructure by combining natural, robust and low-cost technologies.

When the Mariannhill community heard that the city wished to establish a landfill in their area, they set up a monitoring committee to ensure that it did not conflict with their interests.[55] By persistently raising their concerns about the ecological impact of the landfill, they applied pressure on the engineers at Durban Solid Waste and the environmental department at the eThekwini Municipality to pursue a more sustainable design than would normally have been the case.[56] The engineers acknowledged the problems associated with conventional landfills, and were open to trying new methods to prevent environmental degradation at the Mariannhill site.[57]

The project began with an Environmental Impact Assessment, making Mariannhill the first landfill in South Africa to undergo such a study.[58] It found a need to restore local ecosystem functioning, minimise the loss of biodiversity, and connect the site to other nature reserves in order to support natural migration patterns.[59] The Mariannhill landfill had to be designed to prevent environmental contamination, and to restore damaged areas.[60] The key aims of the project were to collect and treat harmful landfill emissions using natural, robust and low-cost methods, and to rescue soil and indigenous vegetation removed during construction and store it in a nursery on site.[61] Other objectives were to help mitigate climate change by reducing greenhouse gas emissions, and to

provide an income to the city through the sale of electricity and carbon credits generated from the captured methane.[62]

The design of the Mariannhill landfill thus included three core approaches:

- **The 'naturalistic' containment, treatment and reuse of leachate**
  Conventional landfill design is responsible for leachate, a liquid waste that can become toxic and contaminate land and water.[63] In collaboration with Enviros UK, Durban Solid Waste designed a treatment system whereby the cells of the Mariannhill landfill are lined with a geomembrane that prevents the escape of leachate, while above the lining a layer of rock and sand allows it to drain off and be collected in a reservoir.[64] Here 30 m^3 are treated by aeration and settlement daily, before being passed through a reedbed.[65] This 'polished' leachate is reused for on-site irrigation and to settle landfill dust.[66] In addition, constructed wetlands help to remove toxic materials.[67] This closed-loop approach means that environmental contamination by toxic leachate is prevented, and water and energy costs of piped council water are significantly reduced.

- **The capture of landfill gas for electricity generation**
  Traditional landfills are responsible for significant methane emissions from rotting organic waste. Methane is ten times as potent as carbon dioxide in its global warming effect, but its impact can be significantly reduced by burning it. The Mariannhill landfill turns this waste product into a resource by using it to generate between 450,000 kWh and 650,000 kWh of electricity per month.[68] This allows the site to generate approximately 200,000 – South Africa Rand – R- (approximately US$22,500[69]) per month from the sale of electricity at a power purchase tariff of between R 0.24/kWh (off-peak) and R 0.36/kWh (peak).[70] Income from the sale of Certified Emission Reductions (CERs) has not yet been received due to the lengthy clean development mechanism process, but about R40 million (US$4.5 million) worth of CERs have been generated since 2007 by the 1MW Mariannhill and 6.5MW Bisasar Road plants together.[71] The Bisasar Road plant on its own has brought in more than R48 million (US$5.4 million) since commissioning. The capital cost of the combined gas-to-electricity project has been approximately R130 million (approximately US$14.5 million), with operational costs of about R10 million (US$1.125 million) per year.[72] These have been partly covered by a R58.74 million (US$6.6 million) loan from the French Development Bank, and a R17.7 million (approximately US$2 million) donation from the South African Department of Trade and Industry.[73] Subject to verification and the sale of CERs, the combined project is expected to break even in approximately 5 years.[74]

- **The protection and restoration of indigenous vegetation**
  The restoration of the original vegetation to closed cells and border areas of the site is another example of how the Mariannhill design surpasses that of conventional landfills.[75] Existing vegetation is usually destroyed during construction, but the Mariannhill design included an onsite nursery called the Plant Rescue Unit (PRUNIT), to save displaced indigenous plants. The Plant Rescue Unit now also provides low-cost rehabilitation to other closed dumps in the area.[76] The saving and propagation of indigenous vegetation supports local biodiversity, and has also provided jobs for people previously unemployed. It has also saved the municipality more than

An aerial view of the Mariannhill Landfill Site. (Source:Durant Civils (Pty) Ltd, 2005'0

R3 million (approximately US$338,000) on new plants.[77] The community's monitoring committee convinced Durban Solid Waste to start a plant rescue process in 1998[78] and worked towards registering the site as a national conservancy, which was achieved in 2002 - a world first for an operational landfill.[79]

The Mariannhill Landfill Site is a significant contributor to urban sustainability. Dependence on fossil fuels and greenhouse gas emissions are reduced by the generation of electricity from landfill gas, the supply of indigenous plants by the on-site nursery, and the re-use of biologically cleaned water on site. Local biodiversity is protected by the restoration of indigenous vegetation, the removal of alien plants, and the creation of wetlands and migration corridors. Economic viability is improved by the sale of electricity and carbon credits as well as the cost savings associated with on-site landfill rehabilitation and reuse of water. The creation of employment, realisation of skills development opportunities, and education programmes each contribute to social sustainability. A community centre and bird hide on the site are used to educate school children about sustainability, landfills, wetlands and the dangers of alien vegetation,[80] helping to spread sustainability messages to the surrounding community.

The Mariannhill Landfill Site is regularly evaluated for effectiveness. It is audited twice a year to retain its permit to operate, and the Conservancies Organisation frequently assesses whether the site should retain its status as a conservancy. The gas-to-electricity project at the landfill is also audited annually to produce mandatory clean development mechanism Monitoring Reports.

The landmark nature of the Mariannhill Landfill Site brought with it significant obstacles along the way. Municipal bureaucracy and the obligations of the Municipal Finance Management Act impaired

the design team's ability to find innovative solutions and required time-consuming reports.[81] The act was a particular constraint on the development of the clean development mechanism project and on the sale of carbon credits.[82] The rate at which the World Bank's Prototype Carbon Fund agreed to buy the Emission Reductions was in retrospect too low to make the project financially sustainable, and the UN's clean development mechanism compliance process was also 'exhausting'.[83] South Africa's shortage of technical skills required to design and maintain landfills and gas-to-electricity plants also proved to be a challenge.[84]

Despite these obstacles and disappointments, a committed and enduring management team and a dedicated monitoring committee have meant that the Mariannhill Landfill Site has achieved its key aims.[85] The willingness of the municipal engineers to think outside the box, and persevere despite the 'red tape' have been vital to the project's success. Perhaps Mariannhill's greatest value is the model it has provided for other landfills to build upon, and other sites such as the nearby Bisasar Road are already improving on its successes in gas-to-electricity production.[86] From this case study, it is clear that managerial commitment and a community-driven demand for accountability are critical to the success of sustainable urban infrastructure.

11. Towards zero waste neighbourhoods in Kampala, Uganda

By Dr. Shuaib Lwasa (Lecturer, School of Forestry, Environmental and Geographical Sciences, Makerere University)

Like many other cities of the sub-Saharan Africa, Kampala is beset by urban environmental management challenges. Solid waste management remains daunting due to the financial, technical, institutional and organizational requirements to ensure adequacy.[87] Although an estimated 40% of the city's annual budget is committed to managing wastes, less than 45% of the wastes generated are collected and disposed off at the landfill.[88]

Approximately 50% of waste generated is left decomposing within the city as a result of indiscriminate dumping in neighbourhoods, leading to problems relating to health, ecological distress and liveability of neighbourhoods. In Kampala, 75% of wastes generated are organic and three quarters of these are peelings from bananas, potatoes, cassava and sweet potatoes. With increasing biomass flows into the city, rotting peels accumulate and cause pollution in neighbourhoods or leachates at landfills.[89]

Against this backdrop, a multi-institutional Action Research project was started under the IDRC-Canada Focus Cities Research Initiative to build urban ecological resilience and address poverty by changing the way in which wastes are managed in the city and its hinterlands. In 2006, Kampala city council partnered with a pilot community of Kasubi-Kawaala, Makerere University and civil society organizations on a program called 'Sustainable Neighbourhood in Focus.' The aim was to mediate between poverty alleviation and ecological resilience in the city by identifying and piloting activities with the potential to reduce waste generation through the recycling and reuse of nutrients

for economically productive activities. Based on estimates of per capita waste generation, peels contributed between 11 and 25 t of waste per day in the pilot neighbourhood. These peels can be recycled to recover nutrients that can be utilized for a number of productive activities by communities. Designed as a three-year 'learning by doing' initiative, the involvement of the community was crucial to the research. This later proved to be even more important in driving innovation.

With a high-density urban community characterized by a mix of predominantly poor social groups and haphazard expansion of neighbourhoods, the provision of waste collection services by the Kampala city council represents a challenge. As its population grows, higher aggregate consumption levels are resulting in increased quantities of biomass passing through the city as residential, commercial, industrial and institutional establishments make use of food and other natural products from its hinterlands. Despite longstanding micro-scale activities to re-use and recycle organic wastes, the value of the resulting waste streams has thus far not been seriously considered in the city's approach to waste management.[90]

The conventional Solid Waste Management (SWM) 'model' designed around formalized city infrastructure and services has largely negated informal settlements, worsening living conditions and creating ecological challenges. This is because the SWM model is not designed to cater for wastes in neighbourhoods with limited or no supporting infrastructure.[91] The pilot neighbourhood was largely residential, so the main challenge was dealing with domestic organic wastes including peelings, banana leaves and food remains from its 15,000 households. Approaches to managing solid wastes varied from open space dumping, compost sites and indiscriminate dumping around the neighbourhood to paid services by private waste collection firms. Through a series of meetings with the community, it was established that some innovative households had started transforming their organic wastes into productive materials such as compost, energy briquettes and feed for livestock. Recycling peels was identified as a practical means of enhancing ecological resilience with social and economic co-benefits in the form of job creation, new revenue streams and improved social cohesion.

Where conventional waste management systems aim to collect, transport and dispose of waste biomass, the innovative use of peels for livestock feed has helped to reduce indiscriminate dumping of waste in poor neighbourhoods. As part of a Sustainable Neighbourhood in Focus pilot project, organized collection and processing systems were set up to convert peels to feed. Households have started separating the peels from other domestic waste and either sell or donate them to a collecting group of KARAMADEG. The collected peels are then spread out on any available surface (including rooftops) to dry in the sun, after which they are milled for poultry feed sometimes mixed with maize bran. Since its inception in February 2008, collected peels have increased from 3 to 40 tons per month.

The weight ratio of raw peelings to dry peels is 6:1, with a yield value of 151.51 kg of feed per ton of peelings. This attracts an estimated 15,000 to 20,000 Shillings (approximately 6 to 8 US Dollars) per 100 kg bag. Combining dried peels with maize bran enriches its starch component by 25%, and reduces the cost of feeds by 36%. It is estimated that the separation of peels reduces neighbourhood waste volumes by over 40%, with clear economic savings for the municipal authority. Even if they are not dried, peels can be fed directly to livestock to create integrated waste-livestock-crop systems that circulate nutrients within the city when supported by urban agriculture. This innovation offers

ecological as well as economic benefits to cities that use large quantities of biomass, particularly in those areas that are less reliant on packaged and processed foods.

Through the collaboration with Makerere University, a chemical and physical evaluation of the peels was conducted for nutrients and any possible risks. Laboratory analysis revealed that the peels have large quantities of protein, starch, fiber and carbohydrates - all of which are important for livestock feed. The re-use of peels thus represents a unique opportunity for value to be created from organic waste that would otherwise have gone to landfill. By recycling nutrients the lifespan of landfills can be extended, and the methane emissions associated with dumping organic waste can be reduced. In areas characterized by inadequate solid waste management, the collection and recycling of organic waste provides an alternative to public dumping, with benefits to health, quality of life, the environment and local economies.

Display of dry peelings. (Source:Shuaib Lwasa, 2011)

The Sustainable Neighbourhood in Focus project finished officially in 2010, but the community is still running the activities as a result of the capacity built and knowledge exchanged. The future of these activities is unclear, but the value behind turning peelings into feed has been realized, and those inspired by the project are teaching others about it and exploring options for scaling up operations. The collection and re-use of organic waste can provide a contextually relevant alternative to conventional solid waste management approaches adopted from the north, particularly in the low income areas of sub-Saharan Africa. Nutrient recycling has the potential to enable more sustainable management of biomass flows through urban ecosystems with significant social and economic co-benefits, and is worthy of more serious consideration as an integrated approach to urban waste management.

12. Sanitation provision in low income settlements in Orangi, Pakistan[92]

By Perween Rahman (Director of OPP-RTI, the Orangi Pilot Project's Research and Training Institute)

Following Pakistan's independence and the partition of India in 1947, Karachi experienced a large scale influx of refugees which more than doubled its population over 4 years. Overwhelmed by the challenge of accommodating these additional people, refugees were allowed to settle in open pieces of land which soon expanded to become unofficial settlements, known locally as KatchiAbadis. In the mid 1970s, the government acknowledged that it was unable to provide land or housing for the poor, and formally accepted these settlements by providing land titles and committing to upgrading the areas. About 60% of Karachi's total population of 15 million live in KatchiAbadis. Some 72% of these areas have been notified by the government, while 35% of the houses have been provided land titles and the remainder are in process.

Government and private land is typically sold to the poor via a middle man, who subdivides the land and uses links with politicians, government departments and private operators to arrange access to services like water. As the settlement expands and consolidates, the need for piped water, sewage disposal, schools and clinics increases, but the government can at best respond in an ad hoc fashion. As a result, community-driven efforts to gain access to services have become commonplace in Karachi.

The Orangi Pilot Project (OPP) is a non-government organisation that was started in 1980 to strengthen people's initiatives to provide water, sewage disposal, schools and clinics in Orangi town, which houses 1.2 million people in a cluster of 113 low-income settlements on the periphery of Karachi. The project provides social and technical guidance within the poor communities, and helps micro enterprises to access credit whilst partnering with government on complementary large-scale investments. It supports communities in financing, managing and maintaining facilities like sewerage, water supply, schools, clinics, solid waste disposal and security at the neighbourhood level. Government invests in larger facilities like trunk sewers and treatment plants, water mains, colleges, hospitals and landfill sites that support the community interventions. By harnessing the willingness of the poor to improve their living conditions, this 'component-sharing concept' alleviates some of the burden placed on government to extend services to the poor.

The OPP's work spans a number of areas, including low-cost secure housing, affordable sanitation, education, earthquake and flood rehabilitation, health education and family planning, credit for micro-enterprises, institution building and community development. It identifies areas for intervention by analyzing outstanding problems in the area, considering which people's initiatives are addressing these issues, and identifying the bottlenecks in these initiatives. Through a process of action research and extension education, viable solutions that promote participatory action are developed and implemented.

The application of the component-sharing concept to the OPP's Low Cost Sanitation Program is an example of how government and homeowners can share the costs and responsibilities of extending

services where government lacks the capacity to act alone. Following 6 months of talking to Orangi residents about their problems and how they might be resolved, inadequate sewage disposal was identified as a major issue. Residents were using bucket latrines, open drains or soak pits, which frequently overflowed into the streets. A few sewer pipes were in place, channeling the waste into neighbourhood creeks, but these had technical faults that limited their effectiveness. Lack of sewage disposal was damaging buildings and health, and households were spending about 500 Pakistani Rupees – Rs- (approximately US$5) per month on medicines and house repairs, limiting the income available to improve their quality of life.

In response to this challenge, the OPP's Low Cost Sanitation Program was established to enable low income families to finance, manage and maintain sanitary latrines in their homes, underground sewerage lines in the lanesand secondary sewers that connect to mains. It also works with government to ensure that the required main sewers, box drains and treatment plants are provided to make these systems work. A team of social organizers and technicians was set up to educate and assist the role-players in implementing the program. Appropriate low-cost technical approaches like pipe laying, jointing and manhole casting were identified following action research into possible options, and these were shared with community and government partners.

> Active community members were identified in each area, and were encouraged to arrange community meetings where slide shows reiterated the problems and demonstrated solutions. Lane managers and masons were selected by the community and trained, and were in turn used to educate participants in other lanes. The managers were responsible for overseeing the project on a lane level, and for collecting the Rs300-500 (US$3-US$5) contribution from each house. The OPP provided them with guidelines for dealing with cases where households were unwilling or unable to contribute, and provided technical assistance throughout the project.

The process of mapping and documenting the existing water and sewage infrastructure in low income settlements and now in the broader city has played an important role in the project, and has supported the process by providing a powerful tool for advocacy and influencing larger-scale planning. A youth program continues to train community architects, technicians and surveyors to map the settlements and plan for the future, and this has promoted the component-sharing model whilst developing valuable skills amongst the youth.

Where large main sewers were required, the OPP-RTI (OPP Research and Training Institute) supported government with its expertise in low cost designs, estimates and monitoring. The project demonstrated that foreign aid was not required due to the availability of local human and financial resources, and this has influenced planning at the city level. For example in 1999, a loan of US$100 million from the Asian Development Bank for a sewerage project for a township in Karachi was cancelled by the government, and the OPP-RTI's low cost alternative was accepted instead. A city-wide network of NGOs, CBOs and citizens has evolved, advocating alternatives to the mega projects in Karachi that promote the use of local resources and the need to build on what exists. Government policies have been influenced, and the OPP-RTI's plan for a realistic sewage disposal system for the city of Karachi has now been accepted by the government.

Orangi Pilot Project Research and Training Institute (OPP-RTI)

The success of the OPP's Low Cost Sanitation Program has not come easily. Over the years, it has struggled with government inconsistency and an ad hoc approach to planning. The scale of demand for services has made it difficult to respond to the large number of requests for support, and a lack of access to information adds to the challenge of disseminating ideas to the poor. The psychological barrier of dependency has been evident in low levels of confidence in people's initiatives, and has been difficult to overcome.

Over the years, the OPP-RTI has learned a great deal about interacting with communities and government to solve problems of service access in a coordinated way. These lessons can be summarized as follows:

- Poor communities have the skills, finances and managerial capacity to help themselves, but they need social and technical guidance to put them to proper use.
- Interaction with communities is needed to understand the extent of problems, how people perceive them and what possible solutions they have tried or would suggest. This interaction in itself starts a process of mutual understanding between the support organisation and the community.
- A technical 'package of advice' should be developed through interaction with the community (including councilors, elders, local leaders and individuals) to foster mutual respect, sharing and learning.
- Both technicians and social organisers are required to adequately support the community - technicians develop the package of advice, and social organizers from within the community share it with their contemporaries.
- Activists from within the community should be identified to support and extend the program.
- A smaller level of organization is better, due to the concentration, time and effort required during the initial stages of a project. This improves understanding and reduces the possibility of conflicts and errors.
- Changing community attitudes can be slow initially, but demonstration has a snowball effect that makes it easier to extend the concept in time.

- Community initiatives need to be respected, accepted and supported by professionals and governments. Community participation is less of a challenge as most communities are trying to solve their problems.
- Master plans are required to document existing and planned work, and should take into account surrounding areas to avoid duplication and resource wastage.
- Continuity of work benefits from working with teams within government departments, rather than with just the head of the department.

The OPP-RTI's Low Cost Sanitation Program has now extended to service all of Orangi town, resulting in significant health and environmental improvements in the neighbourhoods it has affected. Over 105,670 poor households have invested Rs118.7 million (approximately US$1.2 million) in secondary, lane sewers and sanitary latrines, and government has invested Rs807.2 million (approximately US$8.2 million) on main disposals. The model has been replicated by 421 other settlements in Karachi, along with 32 cities/towns and 93 villages covering a population of more than 2 million. The project is an inspiring example of how small scale community-driven interventions – in this case at the level of the lane – can be connected to large government projects to meet the seemingly overwhelming challenges of service extension to the urban poor in a collaborative manner.

13. A simple approach to BRT in Lagos, Nigeria[93]

By Dr. Ibidun Adelekan (University of Ibadan)

Lagos is the hub of business and economic development in Nigeria, and the foremost manufacturing and port city in West Africa. From 305,000 inhabitants in 1950, Lagos's population has expanded to about 18 million.The phenomenal increase in population and economic growth of Lagos has resulted in the spatial integration of central Lagos with its surrounding settlements and those of the neighbouring Ogun state, aided by an expansive road network. Until recently, however, Lagos was the only mega-city without any organized public transport system.

Before public transport, Lagos' 5,180 km of roads facilitated approximately six million passenger trips across the city daily, of which about 75 per cent were transported by the 100,000 passenger buses of different types operated by the private sector. Many of these vehicles were old and in a state of disrepair with serious impacts on the surrounding environment. Rising incomes also led to greater ownership of private vehicles and the proliferation of motorcycles in the city. The existing road network was grossly inadequate, with insufficient tarred roads to meet the needs of the city's population, a limited number of multi-lane arterial roads and generally poor maintenance conditions. The typical journey for commuters from the main residential areas to the north and west of the city to Lagos Island, the largest commercial and central business district in Lagos, could take more than two hours, resulting in time wastage and economic losses. The urban transport system

was typified by congested roads and highways, high fuel consumption, polluted air from vehicle emissions, and an unreliable and inconvenient public transport system.

In response to what had been, until then, insurmountable challenges to the transportation system, the Lagos state government developed a Strategic Transport Master Plan in 2006 to address the multi-faceted problems with the transport system and provide Lagos megacity with an efficient public transportation system within two decades. In line with this plan, a feasibility study for an initial corridor of a Bus Rapid Transit (BRT) system was commissioned in August 2006. The primary aim for the development of the Lagos BRT was to provide more transport choices for all users, with a focus on meeting the mobility needs of the urban poor. Specifically, Lagos BRT was developed to reduce traffic congestion and urban transportation–induced emissions whilst optimizing the usage of the current road network. It also aimed to help the poor by reducing their household expenditure on public transportation and time spent on the road.

The Bus Rapid Transit system called 'BRT-Lite' was implemented by the Lagos Metropolitan Transport Authority (LAMATA), modifying the BRT model by making use of a dedicated lane to prevent interference from other motorists. The BRT-Lite runs along a major commuting route from Mile 12, in the northern axis of the city, through Ikorodu Road to Lagos Island, the largest commercial and business district in Lagos megacity. The design and implementation of BRT-Lite was promoted by study tours undertaken by key transport sector stakeholders to three Latin American countries in 2004 and 2006. This comprised LAMATA officials and representatives of the Lagos state branch of the National Union of Road Transport Workers (NURTW) and Road Transport Employers Association of Nigeria. Visits were made to the Curitiba Research and Urban Planning Consultancy in Brazil, Colombia's Transmilenio BRT in Bogota, and Chile's Transantiago. The tours were used to educate the team and build their support for a Nigerian BRT by exposing them to best practices in public transport.

The 22 km of BRT lanes are designed with 65% being physically demarcated by 400 mm high kerbs, 20% separated by road markings from existing roads and 15% mixing with other traffic. The advantage of this approach is that new road construction for the exclusive use of BRT buses was not required. The carriageways' medians were narrowed instead to ensure that road widths remained, largely, unaltered. Huge savings on construction costs were therefore realized, and BRT-Lite was delivered at a total cost of US$1.7 million per km compared to an average of US$6 million per km for the better known premium BRT systems. Supporting infrastructure consists of a 3.3 metre BRT lane, three terminals, two bus garages, 26 bus shelters, and ten 100KVA generators to provide backup power for street lights. The construction of infrastructure commenced in February 2007 and became operational in March 2008 despite a break in construction work for four months due to the laying of gas pipes in the city. The BRT-Lite took only 15 months to complete from conception to implementation, setting an example for swift implementation of public transport systems to other cities.

The financing of the scheme benefited from the provision of US$100 million credit granted by the World Bank to LAMATA to implement the Lagos Urban Transport Project. This was in addition to a US$35 million contribution made by the Lagos state government. The private sector participated through the financing of rolling stock for 100 high-capacity buses by *Ecobank Plc*.

The wide acceptance of the BRT scheme has been facilitated by involving different groups of stakeholders through community engagement programs. These interactions have ensured that BRT-Lite is seen as a project created, owned and used by Lagosians. Through this approach, a sense of local ownership was developed that resulted in BRT-Lite being seen as designed for its users, rather than for bureaucrats. Third party advocacy was also employed whereby opinion leaders (local government chairmen, local chiefs and community leaders) were invited to discussions on the operation of BRT, and its benefits to the people. This group of stakeholders went on to endorse the scheme in their local communities. A public education campaign on the BRT was also carried out, including advertising along the BRT route and in print and electronic media. Brochures explaining the new system were produced in local languages and distributed to the general public at road-shows.

Demarcation of carriageway on Ikorodu Road (Source: author, Ibidun Adelekan 2011)

Key to stakeholder engagement and wider marketing was the engagement of NURTW and its members at the local level. This was achieved by encouraging the best drivers of large buses to retrain to become 'pilots' of BRT buses. Care was taken to ensure that bus drivers who did not qualify to drive BRT buses would not feel threatened by the scheme, and the operation of their transportation services was restricted to service roads rather than being replaced by the BRT outright. This enabled passengers to choose between transport modes and also secured political and community support for the scheme. New regulations were implemented in 2007 to support the BRT-Lite, prohibiting all vehicles except the BRT-Lite buses from using the designated infrastructure.

BRT-Lite operations have resulted in significant improvements in public transportation within Lagos metropolis, and have contributed positively to urban sustainability. It is estimated that BRT-Lite carries 25% of all commuters along the 22 km route while accounting for just 4% of

vehicles. 10% of trips to Lagos Island are now made using the BRT. A series of boarding surveys conducted by LAMATA indicated that 195,000 passengers travel on the BRT-Lite on an average weekday. Within the first 6 months of the BRT's operation, its buses had carried a total of 29 million passengers.

The use of BRT buses has the potential to mitigate the environmental challenges associated with transport systems, especially in terms of reducing fuel use and consequent emissions of carbon dioxide and other greenhouse gases typically emitted by private vehicles. The BRT system has contributed to reducing urban transport carbon dioxide emissions by 13%. Average journey times have also reduced significantly, in some cases by more than 50 per cent. Furthermore, passenger waiting time at stations has been cut from 45 to 10 minutes, reducing their exposure to air pollution and lowering their risk of contracting respiratory diseases. The major limitation of the scheme is that it is not able to meet demand at peak periods due to limited capacity.

The successful performance of Lagos' BRT-Lite is the result of a holistic approach that has involved not only the provision of infrastructure, but also the re-organisation of the bus industry, private sector financing of new bus purchases, and the creation of a new institutional structure and regulatory framework to support it. Strong political commitment on the part of the state government together with good leadership within LAMATA ensured that the blueprint developed for the system was followed, and that the project was implemented swiftly.

14. Community-driven sanitation in informal settlements in Lilongwe, Malawi

By Lauren Tavener-Smith

Rapid urbanisation and associated growth in informal settlements has aggravated sanitation problems for the urban poor in Malawi. Estimates show that between 1987 and 2010, the urban population in Blantyre, Lilongwe, Mzuzu and Zomba tripled.[94] Faced with limited options for affordable formal accommodation, the largely poor urbanising population meet their housing needs through informal dwellings. Consequently the 'urbanisation of poverty'[95] is associated with a mushrooming of informal settlements.

In Lilongwe, informal settlements expand and densify as poor landlords build rental dwellings on their plots to meet the growing demand for informal accommodation.[96] As part of the rental agreement, landlords provide sanitation services, usually by digging their own pit latrines. With an average of four or five dwellings per plot, a shared pit latrine fills up every 3 to 4 years. Given the problems with pit emptying in informal settlements, it is not uncommon for the full pit to be abandoned and left to decompose while a new pit is dug elsewhere on the site.[97]

Continued reliance on pit latrines in the context of urbanisation and informal settlement growth incurs problems related to land-use competition, environmental contamination and sanitation-related health burdens. The periodic need to relocate latrines when pits become full means that

densification is restricted by the need to reserve space for future pits.[98] This represents foregone rental income for impoverished landlords, and serves to limit the supply of low income dwellings for rent close to the city.

Covering and leaving full pits can contaminate groundwater, with serious health implications if groundwater is used for domestic purposes,[99] which is the case in Lilongwe's informal settlements. A common strategy for people who cannot afford to purchase water from kiosks is to dig a shallow well on their plot to abstract groundwater for household use.[100] Although people know that drinking water from wells near latrine pits is making them ill with dysentery, they continue to do it because they have few alternatives, and because "mostly it does not kill anyone."[101]

New sanitation responses

In 2003, a group of women's savings clubs in Mtandire (an informal settlement in Lilongwe) consolidated to form the Malawian Homeless Peoples Federation (MHPF) and the Centre for Community Organisation and Development (CCODE) was established to support the Federation in their goals related to upgrading services and shelters in informal settlements.[102] CCODE and MHFP are the Malawian affiliates of Slum/ Shack Dwellers International.

When the MHPF and CCODE were established, Mtandire's sanitation problems were visible and urgent. Improving sanitation became salient on the agenda, and since 2004 landlords have worked with CCODE and the MHPF to develop a response which is contextually determined and responsive to households' needs and aspirations. In order to address the needs of the context, new approaches to sanitation needed to:

- Provide a safe way to deal with human excreta on site;
- Be affordable and accessible to the poor;
- Eliminate the periodic need to dig another pit;
- Eliminate the periodic need to relocate the top structure;
- Be convenient and user friendly;
- Be acceptable and desired by users; and
- Support and improve on longstanding practices.

The aim of the initiative was to devise a sanitation response that would resolve problems related to space scarcity in rapidly densifying informal settlements and health problems associated with pit latrines. The improvement of sanitation is regarded as a 'process, not a project,'[103] developed in situ and driven by those directly affected by inadequate sanitation. The approach is pragmatic, as it tries to determine viable solutions through trial and error. The initiative came about via a process aimed at providing sanitation, so sanitation improvements are triggered by the process itself, not the organisation.[104]

When the project began, government responses to sanitation in urban informal settlements were non-existent and aid agencies working on water and sanitation were mostly focused on rural interventions. Government agencies were unwilling to service informal settlements because they feared it would further stimulate their expansion.[105] In the absence of expert assistance, CCODE used the internet to access information regarding design and construction of toilets and over the past eight years the MHPF and CCODE have experimented to find a sanitation technology that is suited to the local context.

Initially, Forsa Alterna toilets were constructed but these proved unsuccessful due to functionality and aesthetic problems that negatively affected social acceptability. User problems with these toilets were taken seriously and triggered a revision of the approach and experimentation with Skyloos began in 2008. Skyloos are urine diverting dry toilets situated atop above-ground, dual-chamber vaults. Urine is diverted into soak-aways or jerry cans, for use as fertiliser. At any one time one chamber is in use while the other chamber is sealed so that decomposition of the faecal matter can occur. It takes on average six months for the chamber in use to fill up, which is approximately the period required for complete composting of the matter in the sealed chamber. By the time the human waste needs to be handled it is benign, and tests by the Bunda College of Agriculture, University of Malawi revealed that, after an additional two-week waiting period the manure was safe to use for growing food crops.[106]

The Skyloo is a form of ecological sanitation (ecosan): it allows for the safe management of human waste without burdening water resources and it facilitates the reclamation and re-use of sanitation by-products.[107] It is interesting to note that this ecological technology was chosen in this case despite a lack of ecological motivations. As discussed above, the initial impetus for the initiative was demand from landlords who saw their traditional sanitation response was no longer viable in an urbanising and densifying world. The determinants of demand are evolving as the benefits of using the compost for growing crops for household consumption becomes more apparent.

Ecosan adopters in Mtandire, Lilongwe. Ecosan adopters are predominantly landlords who invest in the facility for their own use as well as for use by their tenants. (Source: author, Lauren Tavener-Smith, September 2011)

To amplify the natural trajectory of demand, MHPF members who were the first adopters of the ecosan organised into mobilisation task teams. The mobilisation task teams function to create awareness around the space saving, food security and health benefits of ecosan. Once demand has been catalysed, households

that wish to adopt the ecosan work with other sanitation task teams in bringing the construction of the ecosan toilet to fruition.

The demand that is being triggered has to be met with mechanisms that allow the households to invest, as Malawi does not have a subsidy and the focus of agency support is more often rural. Critical is the financing mechanism. Currently two versions of Skyloos are available; a simpler version (with the same functionality but fewer aesthetic frills such as clothes hangers and soap holders for the shower) for 45,000 Malawi Kwatcha - K- (US$122[108]) and a top of the range model for K65,000 (US$177). Householders are responsible for covering the full cost and contribute their labour in the construction. CCODE administers the Mchenga Fund which is a revolving fund backed by funding from international donor agencies and MHPF savings, which makes capital finance available to householders that wish to adopt ecosan. The loan is paid back over a two-year period at 12% annual interest.

Effects of the ecosan initiative

To date, there have been no formal evaluations to isolate and ascribe the impacts of the ecosan intervention. Although causality is difficult to infer without carefully designed evaluations, a number of positive impacts have been observed in parallel with the ecosan initiatives:[109]

- Demand for Skyloos has grown, based on the space saving benefits for landlords and potential gains in household food security[110] and the mobilisation efforts of the Federation Sanitation Task Teams.
- Skyloos free up space for other land uses – instead of the 450 m^2 previously required, 180 m^2 is sufficient to accommodate up to five dwellings.
- Composted faeces and harvested urine are being used, albeit on a small scale, to successfully grow maize for household consumption, sharing and sale.
- Compost and urine have economic value at the household level - not so much as a source of income generation, but more as a means of saving on fertiliser and or food. This in turn allows the households to take the risk of loan repayments on an ecosan investment.
- Less buried faecal matter is linked to reduced groundwater contamination and associated health outcomes.

Formal impact evaluations have less instrumental value to the initiative relative to process evaluation. The former are seen to divert scarce capacity, notably human resources, away from the initiative's primary objective of supporting a sanitation movement driven by the Federation. Informal self-evaluations have been critical in the evolution of the response and are continually undertaken as the initiative develops, with ongoing dialogue between users, builders and CCODE and the MHPF sanitation task teams informing a strategy of improving the design of the ecosan toilets.

Learning from the case study

According to CCODE activist SikuNkhoma, workable and acceptable sanitation is "achieved through a process not a project,"[111] and building a social process around sanitation takes time. This time

endowment would not have been afforded in the context of target driven approaches practiced by development agencies and governments, and this has been the most significant contributing factor to the success of the initiative. A patient process has allowed time for learning so that technology development and social embedding evolve simultaneously. People have watched and seen what makes sense for them, and Skyloos are self-replicating because of the process not the organisation.

The initiative was also able to take advantage of landlords' demand for new sanitation solutions in response to the problems they were experiencing and anticipating. CCODE and the MHPF work with and support those who recognise the impending obsolescence of pit latrines but do not have access to the knowledge, technology or finance to change their circumstances.

CCODE has had to assume multiple roles in addition to their primary goal of mobilising a social process around informal settlement upgrading. CCODE had to develop its own technical capacity and learn about ecosan from scratch before they could begin translating their new knowledge into local action. Without knowledge partners, the process of technology development was unnecessarily encumbered and as a result a number of substandard products were built during the early stages.[112]

The demand for Skyloos is now at a point where additional sources of capital finance. If the scale of demand were to be seriously entertained a partnership with government is required. The social process established around sanitation will benefit the CCODE/MHPF initiative during the initial engagement with government, where the heightened bargaining power of the poor will ensure that the terms of engagement are fair.

The implementation of ecosan technology as a solution to a human problem in Lilongwe shows how human needs can be met using practical, ecologically sensitive approaches. The CCODE and MHPF approach illustrates that the process of understanding what works for a specific context is critical in determining whether the technology will be accepted and demanded by users. Contextual learning has been critical to the success of project, and the ability to learn from mistakes has shaped this response into something which is beginning to self replicate.

15. Aerial cable-cars in Medellin, Colombia: social inclusion and reduced emissions

By Julio D. Dávila and Diana Daste (Development Planning Unit, University College London)

In 2004, Medellín, Colombia's second largest city, implemented the world's first modern urban aerial cable-car public transport system. As a relatively cheap, clean and highly visible response to urban transport problems, it has attracted widespread attention from city authorities throughout Latin America, Europe and Asia. The audacious application of proven ski-lift technology to densely populated and hilly low-income informal settlements was subsequently followed by major neighbourhood upgrading comprising new social housing, schools and other social infrastructure, as well as support

to micro-enterprises. The combination of these two sets of interventions has helped upgrade and integrate into the city's fabric large areas marked for years by severe poverty and violence.

The addition of aerial cable-cars (known locally as *Metrocables*) to the public transport infrastructure in this city of three million inhabitants was an imaginative leap. The first system was built in the poor and inaccessible north-eastern *comunas* (districts). This area is marked by a difficult, steeply sloping terrain broken by deep smaller valleys carved by the numerous streams running down the hillside to the Medellín River. Developed through informal settlements and land invasions in the 1950s and 1960s, by the end of the 20th century it was the most densely urbanised part of the city, with over 400 dwellings per hectare. Minimal road infrastructure made access difficult, although the area was relatively well served by conventional buses and limited numbers of taxis.

The first line was made possible through the combined technical foresight of the city's publicly owned *Metro de Medellín* (Medellín Metro Company) and the political will of a newly elected mayor. It arose from the desire to promote social development in a deprived area, and increase passenger numbers for an underutilised overground mass-transit metro system.

Metrocable Line K with the Parque España library in the background (Source: author, Julio Davila 2010)

Three aerial cable-car lines are in operation (with three more planned), two of which are urban public transport systems (Line K inaugurated in 2004 and Line J in 2008) and a third (Line L) introduced in 2010 to connect with Line K as a tourist route to a nature reserve on the edge of the city. While the first line has been highly successful and runs at full capacity (approximately

30,000 passengers per day), the impact of the second cable-car line suggests that, to be economically and socially significant, cable-car systems require specific minimum conditions in terms of urban morphology and population density, as well as careful integration with the existing mass public transit network.[113]

Cable-car systems are relatively cheap and quick to construct, as little land needs to be publicly acquired and the technology is well-tested. Medellín's cable-car systems are a public sector project, financed jointly by the municipality and the *Metro de Medellín*. Low construction costs make public sector capital borrowing feasible; in Medellín's case all three lines were financed through capital investment budgets. The cost of the first line was close to US$24 million and the second US$47 million, with costs per km comparing favourably with BRT and rail systems. However, due to technical limitations, aerial cable-cars are generally not considered to be mass-transit systems as they cannot transport significantly more than 3,000 passengers per hour.[114]

In 2004, following a change in municipal administration, the area around the first cable-car line became a prototype for social interventions in some of the poorest sectors of the city. This followed a policy of integrating the cable-car systems into the urban fabric through urban upgrading, in a strategy combining mobility, environment, housing and public space, and the goal of creating new dynamic centres in previously economically depressed areas. Municipal interventions across the city also involved increasing and upgrading the stock of social infrastructure such as schools and public libraries, including the construction of distinctive buildings designed by well-known national and international architects. The Parque España Library is one such set of buildings, located close to the first cable car line, and has become a distinctive landmark for the city in a neighbourhood where fear of violence would have kept outside visitors from venturing in.[115] Another distinctive feature of the urban interventions is that the use of local manual labour was made a feature of all public work contracts, while the introduction of participatory budgeting has allowed local communities to collectively decide on the use of some 5% of the municipal budget allocated to these areas for investment.

Although the original drive for implementing the first aerial cable-car hinged on social and mobility considerations rather than environmental ones, potential environmental impacts were considered in the planning stages.[116] Since 2003, the *Metro de Medellín* has sought to formally measure and evaluate the environmental contributions of this intervention through the use of internationally-accepted criteria. Under the aegis of the Clean Development Mechanism (CDM) framework, in 2003 the *Metro de Medellín* prepared a Project Design Document (PDD), which was examined by the CDM Executive Board in 2005.[117] The PDD proposed a baseline and a methodology to monitor the reduction in greenhouse gas emissions arising from the implementation of aerial cable-cars around the world. The proposed methodology was submitted to the United Nations Framework Convention on Climate Change in 2007[118] and validated in 2009.[119]

Baseline emissions were defined as those that would have resulted from the use of other modes of transport to cover the required origin and destination distances. In the case of Medellín, the modes available were minibuses, taxis and jeeps using fossil fuels such as gasoline and diesel.[120] According to this baseline, the replacement of the fossil fuel operating vehicles by a system of hydroelectric-powered aerial cable-cars was projected to contribute to a reduction of up to 121,029 in total

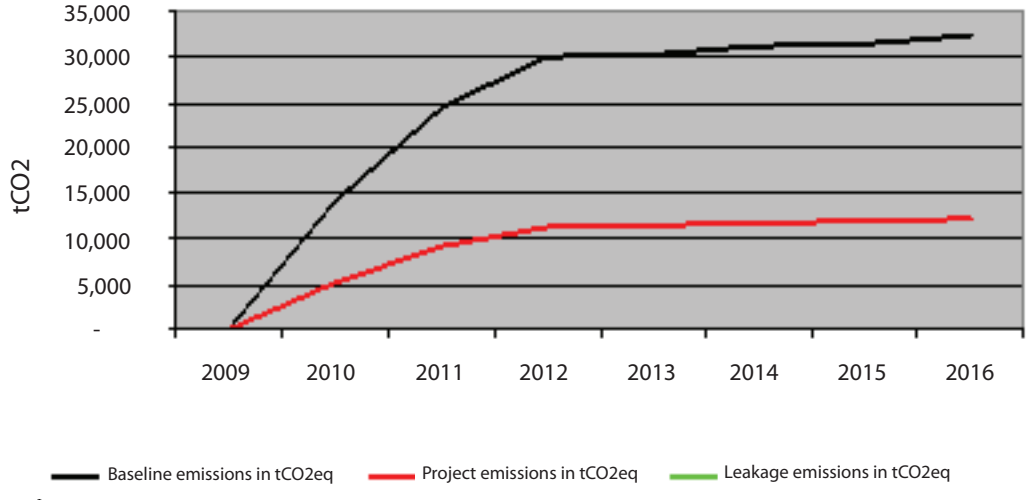
CO_2 emissions between 2010 and 2016). The calculations contemplated the existing three lines and three additional lines projected to begin operations in 2011. In addition, the CDM report states that volumes of trans-boundary air pollutants (mainly carbon monoxide and sulphur dioxide) drop as baseline modes of transport are replaced with a system relying on electricity, generated in Colombia predominantly through the use of renewable resources.[121]

Figure 1: Medellín: Projected emission reductions from six aerial cable-cars

	2009	2010	2011	2012	2013	2014	2015	2016	Total
Baseline emissions in tCO_{2eq}	-	14,005	24,434	30,103	30,382	31,189	31,458	32,311	193,881
Project emissions in tCO_{2eq}	-	5,135	9,083	11,208	11,450	11,724	11,980	12,274	72,853
Emissions reduction in tCO_{2eq}	-	8,870	15,350	18,895	18,932	19,465	19,478	20,038	121,029

Source: Grütter, J. (2009) Cable Cars Metro Medellín, Colombia: Clean Development Mechanism Project Design Document Form (CDM-SSC-PDD), Version 1.3. Unpublished document.

Figure 2: Comparative emissions: Baseline, project emissions and leakage



Source: Grütter, J. (2009) Cable Cars Metro Medellín, Colombia: Clean Development Mechanism Project Design Document Form (CDM-SSC-PDD), Version 1.3. Unpublished document.

Although measurement of the social and economic consequences of the Metrocables is fraught with difficulties, from an environmental and social perspective the impact of the aerial cable-cars can be said to be largely positive on balance. The system has helped to improve the quality of life of the urban poor by making it easier for them to access the opportunities of the city, by enhancing the visibility of the socially stigmatised areas in which they live, and by improving air quality. The first cable car and the associated urban upgrading interventions around the station have given the area higher visibility to outsiders and a sense of social and political inclusion among local residents. Coupled with substantially increased commercial activities around the stations, as well as greater police presence and changes in the nature of the illegal drug business,[122] this has helped to reduce levels of violence and crime in the neighbourhoods surrounding the aerial cable cars.

16. Finnish municipalities working towards carbon neutrality[123]

By Prof. Jyri Seppälä and Dr.Lasse Peltonen (Finnish Environment Institute)

Due to its reliance on energy-intensive industries, Finland's per capita greenhouse gas emissions (GHG) are among the highest in the world, at approximately 15,500 kg/CO_2 per capita each year. While emissions from energy production and major industrial sources have been at the centre of the country's climate policy, less attention has been given to emissions reduction at local level. However, bottom-up measures are gaining popularity as a means of addressing climate change, and leading Finnish municipalities are already pursuing proactive climate strategies.

The Carbon Neutral Municipalities (CANEMU) project was launched in October 2008 in response to the need to reduce emissions at local level. The project is coordinated by the Finnish Environment Institute (SYKE), a national environmental research and development centre operating under the Ministry of the Environment, and it is funded by the Finnish Funding Agency for Technology and Innovation (TEKES). The project operates in five small Finnish municipalities, Kuhmoinen (with a population of 2,700), Padasjoki (3,500), Mynämäki (8,000), Parikkala (6,000) and Uusikaupunki (16,000).

The rationale behind the project is to engage the pilot municipalities (working in co-operation with businesses, local residents and the research community) in a continued effort towards carbon neutrality. Between 2008 and 2010, the municipalities committed themselves to emission reductions exceeding current EU targets. The ultimate aim is to create 'win-win-win' situations, where efforts to mitigate climate change give full consideration to economic, environmental and social factors. The target is to reduce GHG emissions of each municipality by 80% compared to their GHG emissions of 2007, and this is expected to be achieved between 2020 and 2030.

In the first phase of the project, the current GHG emissions were assessed by SYKE in order to establish baseline emissions in 2007. In addition, on-line GHG emission monitoring is now possible for each of the municipalities involved in the project. The relevant energy companies offer weekly data on the use of fossil fuels for the purpose of the calculation system. This feedback is used for

District heating in Parikkala has been converted to renewable sources, mainly wood chips (Source: Olli-Pekka Pietiläinen, Finnish Environment Institute, 2010)

determining municipality-specific targets for reducing local greenhouse gas emissions in both the short term (2-5 years) and the longer term (6-20 years). The most ambitious of the municipalities, Uusikaupunki, has declared a 30% emissions reduction target by 2012 from 2007 levels. The others have yet to determine their short-term reduction targets.

A major initiative of the project involves the mobilization of a broad range of actors to reduce GHG emissions. Collaboration between businesses, local government and citizens is a novel approach compared to earlier efforts led mainly by local government initiatives.Within the municipalities, it is hoped that all target groups – municipal authorities, residents and businesses – will take action to reduce their GHG emissions in the first two years of the project. Such actions will include measures to save energy and improve energy efficiency in homes, public offices, companies and transportation, as well as measures to promote the production and use of renewable energy. The maintenance and enhancement of carbon sinks in the project localities will also be part of the project.

The involvement of businesses has been crucial from the start of the project. Some 30 Finnish companies located outside the municipalities are involved in the project, contributing climate-friendly technologies and services. In fact, the partnering municipalities were chosen on the basis of their links to the project's corporate participants. The project helps these companies to find customers in the municipalities. In addition, local companies play an important role in the project, joining in efforts to save energy and promote the use of renewable energy.

Since the project relies on the successful mobilization of local actors, communication efforts are a very important part of the project. Overall, the project has attracted widespread media attention, which has been instrumental in meeting the project's goals. At the beginning of 2009, public seminars were arranged in each municipality in order to explain the initial emission levels, the aims of the project, and the progress made. In addition, feedback from local people was gathered for planning the next steps of the project. To promote further action, information leaflets were prepared and thematic workshops on the food chain, energy efficiency in buildings, transportation, etc., were arranged in order to create new ideas for reducing the GHG emissions of the municipalities.

In the initial phase of the project, The CANEMU municipalities and local businesses implemented 76 concrete actions. The most important of these included the construction of district heating plants and networks using wood-based fuels in three municipalities. For example, the municipality of Padasjoki switched from oil to wood-based district heating of its municipal buildings, resulting in cost savings of around €200,000 (approximately US$260,000) a year and a reduction in carbon dioxide emissions of 600 tonnes. Lifestyle-related changes included the introduction of climate-friendly vegetarian meals in municipal schools (in Mynämäki and Uusikaupunki) and an online car-pooling system for 'Green riders' (in Uusikaupunki). In the first two years of the project, the most successful of the five municipalities were able to reduce emissions by 10-15%. Based on a theoretical estimate, the CANEMU municipalities can achieve 80% emissions reductions even with present day technology and energy prices. About one third of the reduction can be achieved through energy efficiency measures alone and the rest by replacing fossil fuels with renewable energy.

In order to keep track of emissions and reductions, the project relies on a monitoring system developed by SYKE that compares emissions to the baseline year of 2007. The monitoring of progress in the five participating municipalities is carried out by SYKE researchers and provides crucial and impartial information on the project's effectiveness in terms of actual emissions reductions. The project also maintains an on-line description of measures on the project's website (www.environment.fi/canemu), and the information on the costs of the measures is also being recorded.

The project has been influential in helping municipal decision-makers to embrace low carbon thinking. All of the CANEMU municipalities prepare an emissions reduction action plan annually, and include this as part of the municipal budget. In addition, public opinion in the municipalities has become more climate-friendly. At present, improving energy efficiency in buildings is seen as an investment opportunity, and renewable energy and climate-friendly technologies are seen as new opportunities for employment.

The fact that the CANEMU pilot municipalities are advancing at varying speeds allows for an analysis of the factors that contribute to successful GHG emission reductions. These include:

- Committed municipal leadership, with a clear vision of carbon neutrality in creating business opportunities.
- Responsible and motivated project managers supported by the leadership.
- The integration of mitigative actions in all municipal activities and decisions.
- Support for businesses in promoting energy efficiency, decentralized energy production and the calculation of carbon footprints.
- Media coverage and public displays of the activities such as the public reporting of shared goals and successful measures undertaken.
- Face-to-face contacts to provide information on emissions reduction options and resulting benefits.
- Reliable assessment and monitoring of emissions and reduction effects.
- Inter-municipal co-operation: small municipalities can, for instance, hire an emissions reduction coordinator from a larger municipality to help identify energy efficiency improvements.

The next phase of the project will extend the scope to engage a larger group of municipalities. It will also include indirect emissions through a new calculation method based on a full life-cycle approach, including emissions caused by the consumption of imported products and services in the municipalities. Overall, the CANEMU project can be seen as a pioneering attempt to facilitate concrete climate action in Finnish municipalities through tripartite co-operation of government, businesses and researchers. The observations of the project point to interdependent and compatible roles and resources of different actors, thus enabling them to jointly tackle the global climate challenge through local action.

17. The Eco-Town Project in Kitakyushu, Japan[124]

By Mari Tomita (Ministry of the Environment, Kyushu)

The Kitakyushu Eco-Town Project is a 2000 ha industrial park built on a landfill site facing the Hibiki Sea on the northern outskirts of Kitakyushu City. Started in 1997, its aim is to achieve zero emissions and zero waste by utilizing all waste as materials in other industries, thus closing resource loops within the park.

Kitakyushu Eco-Town came about in response to the city's history as a leading industrial hub throughout Japan's pre-war industrialization, followed by economic growth in the 1960s. Since its first steel plant opened in 1901, Kitakyushu has been home to many heavy industries such as chemicals, steel, glass, cement, bricks, and power generation. With the growth of such industries, pollution became a serious problem. Skies were filled with 'seven colours of smoke' due to red iron oxide particles and dust from coal. The nearby sea was dubbed the 'sea of death' after a study revealed that not even bacteria could survive in its toxic waters.

Birds' eye view of the Kitakyushu Eco-Town (Source: Kitakyushu City 2011)

In the wake of a movement to clean up the environment driven by housewives and women's committees, the city and local companies started taking action to reduce pollution in the 1960s. Actions included the signing of voluntary pollution prevention agreements between the city and companies that stipulated targets more stringent than regulatory standards; the dredging of sludge from the 'sea of death'; the creation of a pollution surveillance centre to check air quality; and the passing of a Pollution Prevention Ordinance in 1971. By the 1980s, the situation had greatly improved, and Kitakyushu's air and water achieved the required national environment standards. The city's success in improving its environment was highly regarded both domestically and internationally, receiving awards such as the 'Global 500 Award' from UNEP in 1990, and the 'United Nations Local Government Honours' at the 1992 Earth Summit in Rio.

In the early 1990s, Kitakyushu's mayor started thinking about the city's next challenge: how to combine environmental policy with industry. This coincided with discussions on how to make best use of its Hibiki landfill site. Study groups were held within the city administration, incorporating not only the environment department, but also calling upon the economic department. The 1990s saw the enactment of basic legal frameworks for recycling and resource management in Japan, including the Recycling Law (1991), Container and Packaging Recycling Law (1995), and the Electric Household Appliance Recycling Law (1998). Together, they established an obligation for industries, governments and consumers to reduce material usage, thus creating a market for recycling technologies. Companies like Nippon Steel were also looking for new business areas as global competition pressured heavy industries to promote rationalization and efficiency. Environment-friendly industries were identified as a key area of opportunity, and stakeholders from industry, research institutions and government joined forces to create the Kitakyushu Environmental Industry Promotion Council.

When the Ministry of International Trade and Industry (MITI) and the Ministry of Welfare set forth their Eco-Town Initiative aiming for the creation of zero resource emitting societies through the strengthening of recycling industries in 1997, Kitakyushu was ready to put its ideas into action. Upon starting, many companies took advantage of MITI's Eco-Town grant. Grants were provided for research to inform planning and engagement with citizens, as well as constructing infrastructure for new companies.

There are two main zones within Kitakyushu's Eco-Town: the Practical Research Area where industry, academia and local government institutions conduct research and development in waste treatment and recycling technologies, and the Comprehensive Environmental Industrial Complex where newly developed technologies are brought to market. Inside the Comprehensive Environmental Industrial Complex is the Hibiki Recycling Area, where the city provides business sites for long term leasing to enable small and medium-sized enterprises to venture into environment-related industries.

Kitakyushu Eco-Town is characterized by a strong collaboration between government, industry and academia. Situated close to the Eco-Town is the Kitakyushu Science and Research Park, where universities and research institutions themed around 'the environment' and 'information' generate new research and build human resources. Universities in the Kitakyushu Science and Research Park received support from the Ministry of Education, Science, Sports and Culture's subsidy for pioneering academic institutions.

Kitakyushu's answer to waste management was to create a system whereby energy and materials are flexibly shared by individual enterprises in different industry sectors. Taking advantage of the fact that the Eco-Town is a gathering of different recycling and reuse factories, residue from one factory is in turn used as material at a different factory. Unusable industrial wastes discarded from enterprises within the Eco-Town (mainly residual substances from recycling and automobile shredder dust) are sent to the complex core facility, where they are processed by melting. In this treatment process, molten material is recycled as slag and metals and the power generated during

the process is supplied to enterprises in the Eco-Town area. With this process, Kitakyushu is able to raise material productivity, recycling and reuse rates, and in turn lower final waste volumes.

Kitakyushu city's strategy of comprehensive development and support resulted in many innovations in the recycling industry. For example, Kitakyushu was the first city in Japan to start the reuse of florescent tubes, and its recycling rate for automobiles is an impressive 99% (exceeding the 95% recycling rate targeted by the Japanese government for achievement by 2015). According to a survey done in 2006, during its first 6 years the construction and operation of Kitakyushu Eco-Town is estimated to have generated 109.3 billion Yen (approximately US$1.2 billion[125]) in direct and indirect investments, and created 6,470 jobs.[126]

Kitakyushu's success can be attributed to a combination of the following factors:

- **Accumulation of technologies and human resources:** The utilization of existing industrial infrastructure and technological capabilities accumulated throughout Kitakyushu's history as a manufacturing center acted in its favor. The technologies, human resources and culture developed whilst combating heavy pollution in the area also played an important role.
- **Timely national policy and subsidies:** New national policies helped to promote new industries like recycling, and timely subsidies encouraged civil enterprises to take on the risks of entering new fields.
- **Communication:** Kitakyushu was very careful to communicate information about the Eco-Town to the public throughout its development. In principle, all facilities were open to public, helping to create the understanding necessary to build support for new waste treatment plants.
- **Clustering:** The clustering of similar businesses allowed them to benefit from shared efforts to communicate and negotiate on behalf of their industry.
- **Motivation:** Having experienced firsthand the hardships associated with extreme pollution, there was a strong appreciation for the need to improve the environment which helped to align interest groups toward these goals.

Having managed to achieve many of its initial Eco-Town Project Plan goals long before 2005, Kitakyushu City started drawing up its Phase 2 Plan in 2002. Phase 2 includes new strategies to promote not only recycling, but also various environmental projects such as energy and resource conservation that promote a more sustainable local society. For example, the city has built a 'Next Generation Energy Park' within the Hibiki landfill site to promote the use of solar photovoltaics panels, wind power and coal gasification. Kitakyushu City has also been working on the Green Corridor Project, aiming at a harmonization of nature within this industrial city through the involvement of non-profit organisations and citizens in the creation of green spaces in the city and educational programs amongst other initiatives. In 2011, the city was selected for inclusion in Japan's 'Future City' Initiative, recognizing the Green Corridor Project as an example of environmental excellence.

18. The City of Melbourne, Australia: Leading by Example

By Stefanie Swanepoel

The city of Melbourne intends to be carbon neutral by 2020 through radical improvements in energy efficiency, reductions in energy and water consumption as well as improved waste management in city operations. Realising the serious threat climate change poses to future economic activity, the city released its strategy document called *Zero Net Emissions by 2020 – A Roadmap to a Climate Neutral City* in 2003, and has positioned itself as a centre for knowledge-based industries.[127]

Melbourne faces problems associated with rising temperatures and declining average rainfalls, and Australia is potentially the most susceptible developed country when it comes to climate change due to its arid climate. The city is also geographically located near a range of vulnerable economies and societies, making it a potential destination for people displaced by the impacts of climate change. The city's low carbon initiative is grounded in the financial merits of early action on climate change mitigation as well as the opportunity to drive the development of new technologies and the business opportunities arising there from. Positioning Melbourne as an international hub of expertise on commercial building retrofits, taking advantage of the increasing demand for energy efficiency technology, applications to increase exports were identified as ways to derive economic benefits for the city and its residents.[128]

Updated in 2008, the plan will be constantly reviewed in order to take advantage of the latest science and technological advances in climate change knowledge and best practices of successful implementations in other cities of the world.

The Importance of Partnerships

Driven by the city, in partnership with other regional, state and national bodies, the initiative focuses on three broad strategies: leading edge design, de-carbonising/greening the power supply and carbon offsetting. All three strategies have action items aligned to them with specific timeframes for implementation. This initiative was rolled out in the context of international and national treaties including the 2005 European Union Greenhouse Gas Emissions Trading Scheme, Australia's ratification of the Kyoto Protocol in 2007 and the commitment of the Australian government towards an Australian National Emissions Trading Scheme. Melbourne is also part of the C40 Large Cities Climate Leadership Group. The plan is also envisaged as a 'blueprint' for other Asia Pacific Economic Cooperation (APEC) countries.[129]

The city's primary focus on the mitigation of its own operations is premised on the belief that by setting an example and implementing strong policy guidelines whilst making information and incentives available to both residents and businesses, they will follow suit. This initiative has been galvanised by a combination of policymaking, financial measures, innovative urban design and specific programmes to address target areas.

Examples of policy or financial instruments used include measures such as direct investment or grants and subsidies, as well as penalties for non-compliance. The city also has the option of buying, selling and developing land in its own right, making representation to state and federal government on policy and regulation, and zoning and regulatory powers. Capital investment for this initiative was projected to come from encouraging private finance to invest in 'green' buildings and technologies, taking advantage of the natural cycle of rebuilding and refurbishing in Melbourne to improve design and energy efficiency[130] under the guidance of regulations. The city would fund its own transition to carbon-neutrality, as reduced energy use would translate into lowered operating costs in the long-term. The aim of the plan is to support innovation and assist in the development of both service and technology products that could be exported.[131]

Energy, Buildings, Transport and Food

The 2008 figures showed a reduction of 41% in city operation emissions from 1997,[132] close to the interim target of 50% by 2010. Primarily achieved through the implementation of energy efficiency measures in public buildings and lighting; public engagement initiatives have seen further reductions in emissions. These include the Postcode 3,000 programme encouraging people to move back to the inner city by providing financial incentives as well as technical and street-level support. The mandatory requirement for extensive developments to have energy performance ratings of 4.5 stars under the Australian Buildings Greenhouse Rating Scheme (ABGR); the implementation of a house auditing programme; and the CitySwitch Green Office alliance, which works with commercial building tenants[133] have all contributed to reducing energy emissions in the building sector.

RMIT University, Melbourne (Source: Yongpeng Shen, Victorian Eco-Innovation Lab, 2009)

The Cycle Melbourne scheme, which combines bicycle hire, end-of-trip facilities and bicycle networks will see a 100% increase in bicycle use by 2014. The city is looking at establishing a gas-fired power plant to specifically power public transport, and policy amendments include the requirement that public buses entering Melbourne have to use low-carbon or clean fuel by 2012.

Given the prolonged droughts that Melbourne experiences, there is a commitment to reducing water consumption by 40% by 2020.[134] Some direct actions already taken include the gradual replacement of city parks and sports grounds with drought tolerant grasses; the use of reclaimed water for irrigation purposes; and use of extensive mulching to improve water retention. A free showerhead exchange initiative reduces the amount of water used per person per year by 13,500 litres[135] and citizens are encouraged to collect rainwater for garden irrigation.[136] Water restrictions are in place in the city with compliance enforced.

The Ecological Business District, a vision of the Victoria Eco-Innovation Lab, is a mixed-use residential project and research space that generates renewable energy, treats water on-site to return to the city's catchment area and produces food for sale and further processing. It has stimulated the growth of eco-innovation businesses as well as the commercialisation of low-carbon technologies.[137] Residents are encouraged to reduce food waste and private enterprises have emerged offering services around waste collection, composting as well as the distribution of surplus food.[138] Farmers' markets are growing in popularity and the four largest have banned the use of plastic bags and encourage traders to find alternatives to conventional tasting cups and plastic containers.[139] Commissioned research for the state shows the importance of land use obtaining multiple outcomes including food, energy, biodiversity and carbon sequestration.[140]

Why it works and the way forward

Both the use of policy to shape development and the decision to set an example for residents by concentrating on reducing the city's emissions have been key factors for success. Information is readily available for citizens and businesses wanting to move towards a low-carbon future. Population growth and the increased adoption of energy intensive appliances like air-conditioners make energy reductions challenging. However, this is seen as an opportunity to drive economic growth with the Melbourne Fund encouraging investment in technologies for wastewater treatment, recycling, renewable energies, retrofit, and design companies[141] to provide further incentive for private industry involvement. Less progress has been made in terms of large-scale de-carbonising of power supplies because of the need for support from a wide range of parties to overcome the barriers such as a lack of institutional mechanisms and industry experience, as well as the entrenched interests of centralised energy retailers and distributors. It is hoped that the Australian governments' commitment to a national emission scheme in 2010 will help to propel this strategy further and drive investment in renewable energy supplies.

19. The Climate Action Plan of Portland, Oregon

By Stefanie Swanepoel

In 1993, Portland was the first local government in the United States of America to institute a policy around anticipated global warming. Multnomah County – of which the city is a part – joined this initiative in 2001, and the culmination of these policies was an integrated, city-based plan to prepare the region for potential climate change impacts called the Climate Action Plan (CAP). The primary goal of CAP is to reduce the carbon emissions of the county and city by 80 per cent from 1990 levels by the year 2050.[142]

Perceived threats to the region include changes in weather and rainfall patterns that could affect stream flow leading to flooding and low groundwater recharge resulting in drought.[143] Specific threats include those to power supplies, food and water sources, public safety and health as well as local economic decline due to the rising cost of fuel and continued degradation to the natural resource base in and around the city. An additional 'threat', due to its relatively cooler Pacific Northwest location, is that the region might become a favoured destination for people seeking relocation from areas affected by climate change.

Recognising that climate change, deepening social inequities, degraded environmental systems and rising energy prices are related challenges, CAP sets out a range of interlinked objectives to address the inherent complexities. By reducing and redirecting existing resource flows (energy, waste and food) through the city and county, they hope to increase both the resilience and adaptability of the region to climate change as well as radically reduce carbon emissions. The first status report on the progress made by CAP was released in December 2010.

Translating CAP into reality

The CAP initiative is the result of collaborations amongst county and city governance structures, members of the public, businesses, academic institutions, and non-profit organisations. It aims to achieve its ambitious emission reduction goal through eight core areas of action: buildings and energy; urban form and mobility; consumption and solid waste; urban forestry and natural systems; food and agriculture; community engagement; climate change preparation; and local government operations. The plan is a holistic one that integrates economic, environmental and social imperatives; it is also iterative in that there are built-in opportunities to review, revise and change the focus.

An enabling city, regional and state context

When CAP started, coordinated carbon emission reduction efforts at the regional and state level were already in place and a cap-and-trade system for the larger region (the Western Climate Initiative) had recently been introduced. Portland, through sound land-use management and previous investment in public transport infrastructure, had already managed to reduce emissions close to 2000 levels.[144] The supportive environment was further enhanced by the state and local policy environment, existing transit and bicycle infrastructure, a tax credit system to encourage alternative energy consumption and production as well as progressive land-use and building codes

which encouraged development geared towards 'green' transit options and the creation of dense, mixed-use buildings.[145]

Portland's economic vision revolves around the harnessing of the potential that the green economy offers the city[146] and aims to position itself as a leading centre for sustainability in the United States. It was already home to a significant concentration of renewable energy firms as well as strong recycling, green building and environmental services sectors.[147] Human resources include a growing supply of experienced workers for the clean technologies industry (84% higher than in similar-sized regions for renewable energy), and environmental services and recycling.[148] The 2009 Portland Economic Plan closely aligns with CAP to ensure that growth and investment is guided along the lines of carbon emission reduction; introduction of renewable energies and alternative water technologies; and pursuing opportunities for local manufacturers to fill supply chain gaps and replace imported components for the clean tech industry.[149]

Portland has therefore significant knowledge resources to draw upon, including academic resources from local universities, but sourcing finance for investment purposes remains a challenge,[150] particularly in the current economic climate.

Bicycle Bridge (Source: City of Portland Bureau of Planning and Sustainability)

Is Portland's CAP working?

Portland's emission reduction target is broken down into specific objectives that have measurable action points attached to them. An interim goal of a 40% reduction by 2030 has been set with emissions being reported on annually. The plan will be evaluated every three years and rewritten every ten. The 2010 annual status report indicates that carbon emissions decreased by 15% between

2000 and 2010, resulting in emission levels that were 1% below 1990 levels,[151] despite a 24% increase in population over that period.[152]

CAP focuses on reducing emissions through a combination of high and low-tech initiatives. These include the implementation of policy restrictions around building materials in order to reduce emissions, investments in public transportation and the encouragement of bicycle use. Over 24 km of bicycle friendly streets have been built and '20-minute neighbourhoods' have been promoted to enable residents to meet all of their non-work needs by walking or cycling as opposed to driving. A 2010 assessment found a 10-15% reduction in single passenger vehicle trips and a 2.6% increase in the use of public transportation in the space of a year.[153]

Lowering the carbon-intensive nature of the food system and improving the vibrancy of the local economy and the health of citizens is based on increasing local food production and consumption though supporting urban farming, demonstration gardens and unemployed youth training schemes, including food issues in the school curriculum and encouraging farmer's markets and community supported agriculture schemes (CSA). In 2010, in addition to the existing 32 community gardens, 150 new ones were opened, along with a CSA farm and a further 75 gardens in partnership agreements.[154] A Food Policy Council is in place and information about local food – both growing and purchasing it – is readily available on the city's website.

The plan also recognises solid waste as a resource flow that can be radically minimised through increased recycling efforts and encouraging residents to be aware of how much waste they generate. A food-scrap collection programme that transforms food waste into compost has been launched at municipal composting facilities, and this is in turn used to enrich the soil in urban farms and gardens. Standards for household and business recycling collection are currently being developed. By 2010, the city had decreased total wastage by 8% from 2008 figures.[155]

Substantial investment has been made in renewable solar power energy options for homes, neighbourhoods and businesses with up-front financing provided for both purchasing and installation,[156] as well as incentives for conversion to less carbon intensive energy sources and reduction of energy usage in homes (more than 3,000 homes in 2010 alone). The city has installed five MW of solar energy and is in the process of doubling its renewable energy capacity through investments in wind power, which currently supplies just over 4% of power to the region. Hydroelectric sources supply close on 50% of the region's power, and the balance is supplied by coal (37%), natural gas (12%) and nuclear (4%). A 279 kW solar electric system has been installed at city premises, and overall reductions in energy consumption have allowed for an approximate 19% savings on the city's annual energy bill of US$18 million.[157]

Lessons from Portland

The emphasis on strong policy action, extensive public-private partnerships, as well as active community participation has been pivotal. Policymaking focuses on creating an enabling environment for a range of interventions while partnerships have resulted in collaborations around a range of issues. Public participation has been strongly encouraged through campaigns, and information about the initiative is easily accessible.

One of the challenges is a lack of standardised quantitative measuring tools available for aspects such as the absence of waste and carbon emissions from the production, transportation, use and disposal of goods. Funding is also limited, particularly for transport infrastructure which is currently funded by the tax on fuel, and some of the action items have uncertain funding from 2013 making long-term planning difficult.

The citizens of Portland have benefited through improved infrastructure and easy access to renewable energy sources that offer them direct cost savings. The city is in the process of formally assessing the region's vulnerability to climate change so that it can anticipate and manage risks, increasing its adaptability and resilience.

20. The 'Green Vision' of San Jose, California

By Natalie Mayer

San Jose's Green Vision is an ambitious 15-year plan to address climate change and promote economic growth while enhancing citizens' quality of life. The plan capitalises on the city's access to Silicon Valley, the heart of clean-tech innovation in America. The third largest city in California, San Jose is no stranger to environmental action. The city has enjoyed high recycling rates, water conservation strategies, energy efficiency and alternative energy programmes as early as the 1980s.[158]

However, in 2006, San Jose's carbon emission figures were still high relative to California's carbon emission reduction targets, and the city was growing concerned that it was falling behind.[159] Emission reductions required significant technological development, as well as the quick commercialisation and uptake of clean technologies.[160] The city's location in the heart of Silicon Valley thus presented significant opportunities as the region is well known for its ability and willingness to innovate and adapt, having led numerous developments from defence technologies in World War II through to modern computers and software.[161] San Jose residents produce the greatest number of patents per capita out of all American cities, and enjoy the highest level of venture capital investment per person.[162] The city therefore is well positioned to benefit from the innovations in clean technology required to mitigate climate change.[163]

These realisations led San Jose's mayor, Chuck Reed, to draw up a Green Vision for San Jose in 2007, after months of discussion with stakeholders.[164] The vision paves the way for the city to become the world capital of clean technology innovation and leader of urban sustainability, via ten ambitious goals:[165]

- Create 25,000 clean tech jobs by 2022;
- Reduce energy consumption per capita by 50%
- Receive 100% of electrical power from renewable sources;
- Build or retrofit 50 million ft² of green buildings;

- Divert 100% of waste from landfill and convert waste to energy;
- Recycle or beneficially reuse 100% of wastewater;
- Adopt a general plan with measurable standards for sustainable development;
- Ensure 100% of public fleet vehicles run on alternative fuels;
- Plant 100,000 new trees and replace 100% of streetlights with smart, zero-emission lighting;
- Create 100 miles of trails connecting with 400 miles of on-street bikeways.

Implementing the Green Vision

San Jose aims to add 25,000 jobs in the clean tech sector by supporting start-up and existing companies through grant support, permit assistance, networking, and offering city land and buildings for demonstration projects. Energy consumption is being reduced through partnerships with residents and organisations to measure energy use and implement efficiency measures. To receive 100% of its electricity from renewable sources, the city is promoting solar energy by supporting power purchase agreements and public-private partnerships.[166]

5 million square meters of buildings will meet LEED certification standards, through San Jose's support of innovation, raising of awareness and providing of financial incentives. 100% of waste will be diverted from landfills through better material management, recycling, and the conversion of solid and liquid waste into electricity or fuel. 100% of the city's waste water is to be reused by connecting more users to the recycled water system. The Envision San Jose 2040 General Plan measures progress towards sustainable development.[167]

The city's entire public vehicle fleet will run on alternative fuels through the purchasing of specialised vehicles, expanding plug-in stations and alternative fuel depots, and supporting the development of energy-efficient vehicles. 100,000 new trees will be planted with the combined

Google Complex in Silicon Valley, near San Jose (Source: Sebastian Bergmann, 2011)

help of the city, community organisations and residents. Streetlights will make use of LED lighting with smart network control and monitoring systems to reduce energy use. Finally, 160 km of trails will be established by identifying and purchasing land that connects with on-street bike paths.[168]

Implementation is driven by individual goal leaders, while the entire project is overseen and facilitated by the City Manager's Office. There is increasing emphasis on partnerships between the city and the private sector. Achieving the vision relies on city funds and on grant funding from the county and the state, but these are limited so the city is exploring alternative funding mechanisms.[169]

Improving city sustainability

Greenhouse gas emissions (GHG) that exacerbate climate change are reduced by increasing the uptake of renewable energy and energy-efficient products, recycling solid waste and waste water, using alternative fuels, planting trees, and encouraging walking and cycling. Water is saved by the recycling and reuse of waste water, and land is used more efficiently and is less polluted as the need for landfills is reduced by better waste recycling. Socio-economic sustainability is improved as the creation of jobs and growth of local industries means that more money remains in the region, welfare costs for the unemployed are reduced, and quality of life improves. Besides reducing carbon emissions, the extensive biking and walking trails help to improve people's health and allow those from different backgrounds to mix.[170]

By 2010, progress made towards San Jose's Green Vision goals was as follows:[171]

- 4,350 clean tech jobs have been created;
- Per capita energy use has fallen by 2.4% (4.8% of their target figure);
- 15% of the city's electricity comes from renewable energy sources;
- Over 3.7 million out of the 50 million square feet of certified green buildings have been completed;
- 74% of waste is diverted from landfills;
- 21% of waste water is recycled or beneficially reused;
- A full Draft Plan document has been completed;
- 42% of city fleet runs on alternative fuel; GHG emissions have been cut by 28% (2003 baseline);
- 4,500 new trees out of 100,000 have been planted;
- 0.5% of streetlights have been replaced with smart zero-emission lighting;
- About 85 km of the goal of 160 km of trails have been created. In the last four years U.S. Census has indicated a 125% increase in bike trips in San José, 50% above the national average.

Challenges

Progress towards the Green Vision goals can be attributed to the ability of each department to prove that their programmes contributed materially to the results that the city desired.[172] However, financing has been difficult and the city has had to leverage outside resources and create strategic partnerships to supplement internal funding.[173] This will have to continue and be even more effective if the Green Vision goals are to be reached by 2022. Some critics have suggested teaming up with other cities to ensure uniform standards across Silicon Valley for greatest effect and least disruption to the business community.[174] Others wonder if it is wise to invest so much in emerging industries that are likely to consolidate as they mature.[175] There is also uncertainty as to who will be responsible for reaching the goals when Chuck Reed's second term as mayor ends in 2014.[176]

Conclusion

Though ambitious, San Jose's Green Vision has a good chance of success due to the city's location in Silicon Valley, its history of innovation and its citizens' willingness to try new things. If external funding can be found, and certainty reached on who will see the project through its remaining years, achieving the ten goals is possible. Progress to date is already establishing the city as a world leader in both clean technology and urban sustainability.

21. Singapore: doing more with less water

By Stefanie Swanepoel

The island-state of Singapore has undergone one of history's fastest transitions from a developing economy to a leading first world economy. It has one of the highest per capita incomes in Asia and its population is slowly increasing to close to five million people.[177] However, Singapore has a finite amount of land, limited water resources and a growing population dependent on imported energy, food and water; and all of this in the face of climate change challenges.

The country is dependent on global trade for access to the resources that it needs for economic growth, and the rising cost of resources such as oil, energy, raw materials and water will increasingly place pressure on Singapore's ability to maintain its economic growth. Currently Singapore imports most of its food and water as well as the resources and raw materials needed for industry, including construction materials and oil.[178] In addition, it is vulnerable to climate change impacts such as flooding, loss of coastal land and changes in fresh water resources.[179] The city has acknowledged the importance of securing access to resources, conserving energy and reducing water use, in other words, doing more with less to decouple the future growth of the city from increased resource use.

In 2009, Singapore released Sustainable Singapore Blueprint, a plan that would allow for economic growth within the limitations posed by resource scarcity and rising resource prices. It rests on four primary principles: those of improved resource efficiency, improved environmental quality, increased

knowledge about sustainable development, and community ownership.[180] Aggressive goals have been set in all four areas to be met by 2030, including a 35% improvement in energy efficiency from 2005 levels, achieving a recycling rate of 70%, improving accessibility for pedestrians and cyclists, as well as reducing domestic water consumption to 140 litres per person per day.[181]

The 'Singapore Way'

Aligning economic growth within environmental sustainability has meant the acceptance of certain operating principles that have come to be known as the 'Singapore Way'; these include the importance of integrating and aligning planning, taking a long-view of development although it entails short-term costs, and being flexible in approach because many changes in technology and the global environment will be coming in the coming decades.[182]

NEWater Visitor Centre, Koh Sek Lim Road, Singapore (Source: PUB, Singapore's national water agency, 2009)

In 2008, an Inter-Ministerial Committee on Sustainable Development was set up to craft a strategy to ensure Singapore's sustainable development in light of domestic and international challenges. The result was the Sustainable Singapore Blueprint that was jointly created by government, public and the private sector in an inclusive and participatory process including input from media editors and academia.[183] Goals will be reviewed every five years and adapted to improvements in technology and international developments, and the government will monitor and inform the public of progress.[184]

1 billion Singapore Dollars -$- (US$808 million[185]) was set aside by government as a budget to support the roll-out of the initiative and since 2009 additional investments have been allocated, in particular for improving energy efficiency in buildings, improving public transportation and for testing solar technology and applications.[186] Almost S$700 million (US$565 million) of the

initial funding was set aside for research and development and manpower training, with large allocations for implementing and incentivising the Green Mark efficiency system for buildings and the installation of solar panels. Testing for the viability of electric vehicles was conducted in 2010 and part of the budget was set aside to build cycling networks.[187] It is estimated that the investment of S$680 million (US$549 million) to build capability in the energy and water technology sectors could contribute a value-add of S$3.4 billion (approximately US$2.7 million) to these industries and generate employment of close to 20,000 people by 2015.[188]

Water for All: Conserve, Value, Enjoy

One of Singapore's biggest success stories is its water resource management. Water sustainability and security is vital for Singapore as there is no groundwater and the land area is not sufficient for collecting and storing water to meet its requirements.[189] Although it has historically low water consumption levels in comparison to other first world countries, when its two water agreements with Malaysia end in 2011 and 2061, the price that it pays for water could increase radically, making it difficult for government to ensure affordable and adequate supplies.[190] The interim goal of the Sustainable Singapore Blueprint initiative is to reduce domestic water usage from 154 litres per person per day (2009 figures) to 147 litres by 2020, and 140 litres by 2030.[191]

Over the past four decades, the government has invested considerably in research and technology for water conservation, and in implementing the first stage of a deep tunnel sewerage system to redirect waste water flows towards water reclamation plants.[192] The current water supply is drawn from four sources, known as the 'Four National Taps': the local reservoir catchment, imported water, NEWater and desalinated water.[193] NEWater refers to the collection, treatment and purification of used water using advanced technologies, rendering it even purer than WHO standards and perfectly safe to drink.[194] It is estimated that at the end of 2011 NEWater would meet 30 per cent of the nation's needs once the fifth plant has been completed.[195] Singapore currently has one of largest desalination plants in Asia, using reverse osmosis to transform seawater into drinkable water. In 2010, this plant was supplying 136,000 cubic metres of fresh water per day providing for roughly 10% of Singapore's water needs.[196]

In efforts to reduce the amount of water used and wasted, lessen their dependence on imported water and prevent water wastage through leaks, a series of projects have been launched to clean up the Singapore River, increase the number of reservoirs, fix leaks in the water distribution system and encourage the public to reduce their water usage.[197] These water conservation programmes include a 10% Challenge and 10-Litre Challenge to citizens, schools and businesses to use water responsibly and save.[198] A Watermark Award is given annually to individuals and organisations that have significantly contributed to the 'water cause'; those who raise awareness around water issues in Singapore are recognised in the Friends of Water Programme and an Our Waters initiative encourages schools to adopt water bodies and look after them.

In 2010, the number of leaks per 100 km of potable water pipelines had been reduced by 1.2%, and the number of sewerage disruptions per 1,000 km of sewer lines reduced by 6% from 2007 levels. During the same period, the number of reservoirs increased from 14 to 17, sales of NEWater increased from 49.2 to 96.4 million m^3, and sales of industrial water (non-potable, reused water) decreased by five million cubic metres.[199] Progress towards the goal of 140 litres per person per day

in 2030 is ongoing as consumption has decreased from an average of 165 litres per person in 2003[200] to 157 litres in 2007, and 154 litres in 2010.[201] The Singapore government has stated that the country can be self-sufficient in water by 2061 when the water agreements with Malaysia expire.[202]

What can be learnt from Singapore?

The very clear vision presented by the Singapore government following extensive public and private sector participation combined with strong commitment to action has been vital for the success observed thus far in this initiative. The focus on integrated planning at all levels and the inclusion of the public in education and awareness campaigns has also been extremely important. Citizens of the country have benefited through cost savings of energy- and water-efficient appliances following the mandatory labelling campaigns as well as through being able to enjoy the cleaner city; lifestyle events held at reservoirs and waterways increased from 74 in 2007 to 288 in 2010 signifying the increased value and appreciation that Singapore's citizens place on its water.[203]

22. The Transition Network and Community-led sustainability in Totnes, UK

By Damian Conway

The Transition Network (TN) was founded in the UK in 2007 to "inspire, encourage, connect, support and train" communities to envisage, plan and implement locally appropriate strategies for dealing with the looming pressures of peak oil and climate change.[204] TN's mission is predicated on the belief that to successfully transform *physical* infrastructures for more sustainable and equitable resource flows, the underlying *social* infrastructure must have the capacity to participate in and preferably even drive this transformation.

Rather than relying only on government to make the appropriate infrastructural investments in preparation for resource scarcity and climate change, the transition approach supports an unconventional bottom-up response that recognises the potential for motivated communities to influence and reconfigure their local infrastructures and socio-economic networks. Thus TN provides training and resources, including handbooks, courses, and documentaries, stages events and maintains a web-platform to support collective civil capacity building and action (in neighbourhoods, villages, cities, regions.[205]

Although the transition approach does not prescribe outcomes and timelines, some of the older transition initiatives have drawn up their own exhaustive 15-20 year Energy Descent Action Plans (EDAPs) that are locally specific working plans for moving towards a robust, sustainable, energy efficient urban future.[206] Furthermore, although it is able to guide communities to tap into its growing network of technical experts, TN is not a technical training or information resource. However the projects that are born of the numerous transition initiatives around the world are usually very practical in nature, often interfacing with existing urban infrastructures for supplies and flows of energy, food, transport, goods and services.

Transition Town Totnes (TTT) is the oldest transition initiative. It has 10 active groups and 32 transition projects underway.[207] Some examples are:

- Totnes Renewable Energy Society (TRESOC) which has formed a community-owned company with four energy projects in development: a 4.5 MW wind farm; an aerobic digestion scheme; a biomass boiler; and four potential solar farms ranging from 30-50 kW peak capacity.

- Transition Homes Group which has set up a trust that aims to provide low-cost housing and neighbourhood infrastructures (for water, sanitation and food production) based on ecological principles of metabolic flows. Local, non toxic materials will be used for construction. Residents will participate in the physical building process, learning useful skills for future developments.

- The Transition Streets project which has so far seen the formation of 59 neighbourhood groups of 6-8 households each (50% low-income). These groups are working collectively to implement energy changes (behavioural and technical) to reduce household carbon emissions and energy bills by 2.1 t per year and £600 per year respectively (US$910).

The population of Totnes is relatively small at around 8,000 residents. Nevertheless, a recent survey found that 57% of local people feel that TTT's work is either 'highly relevant' or 'relevant' to their lives. Gradually, economic enterprises have begun to spin out of the initiative such as the Totnes Sustainable Construction Company Ltd, TRESOC, the Totnes Pound, and the Totnes Food Hub.[208]

Transition initiatives have been successful where actors have had the skills, motivations and private resources to contribute to or even lead collective local responses to climate change and peak oil. Through a 12-step, tool-oreinted process of awareness building and community, more and more actors are drawn into the local initiative who then form groups in areas of personal interest such as food, energy, transport, and enterprise. The process is designed to attract people in local communities by advocating not only the economic and moral imperative of getting involved but, perhaps more importantly, the opportunities to be a part of an enriching experience that builds local community and strengthens social and economic resilience.[209] More and more pre-existing projects around the world are adopting the transition banner which is rapidly gaining an international reputation for embodying certain universal principles for positive civil action.[210]

At this stage TN, which is active mostly in the global north, recognises that the types of people who are getting involved are generally those who have the resources, time and capacity to participate (normally on a volunteer basis). Hence the networks that are being created may be at risk of inadvertently under-representing poorer sectors of local communities who are the ones in most urgent need of practical solutions to rising living costs. However, gradually projects are emerging in poorer areas such as in disadvantaged neighbourhoods in Glasgow UK, in economically depressed cities in Eastern Europe and even in the Favelas of São Paulo, Brazil.[211]

To-date approximately 3,000 people have attended training courses provided by TN. It is estimated that, 1900-2500 transition initiatives have sprung up around the world (mostly in the global north). Many of these initiatives have started of their own accord with little or no direct contact with TN. There are approximately 400 officially endorsed initiatives, and 800 listed on the TN website.[212] TN is funded from grants, donations and revenues from selling training resources.

TN has thus far not conducted any formal research on the impact of the various initiatives on local resource use and infrastructure transformations. As the transition ethos and practice spreads, it becomes increasingly difficult to monitor impacts. For TN the exponential growth of interest around the world is a positive sign of a growing network of locally appropriate and relevant responses. The individual initiatives are better equipped to assess the impact of their activities on urban sustainability. TTT, for example have detailed statistics on the impacts of their various projects.[213]

Reasons for the success and popularity of the transition movement include:

- TN's emphasis on the importance of local communities defining their own responses to environmental and resource pressures. TN encourages the duplication of its efforts around the world without seeking to control outcomes.

- TN's emphasis on global pressures as a catalyst for community-building rather than just as a threat. The TN training courses expose people to innovative, energising ways of working democratically and productively in groups, drawing on principles of collective visioning and decision making that for many is transformational.

- The promotion of incremental responses. TN encourages small steps that allow working groups to gradually build confidence and cohesion.[214]

Looking to the future, the Transition Network faces the challenge of finding ways for more disadvantaged communities to access and make use of the transition resources in order to make meaningful improvements to their urban lives. To address this, TN has hired a Diversity Coordinator who is helping to develop strategies to maximise inclusiveness and address the needs of a broad spectrum of people within the various transition communities. A further challenge is that as local projects grow in scale they inevitably begin to interface with government policies and plans for infrastructure investment.[215] At this level there is a need for a new form of engagement and partnership. Without the support of local government, the extent to which transition initiatives are able to influence the reshaping of existing, publically owned infrastructures is limited. These initiatives are then at risk of having to bypass existing infrastructures – creating their own collectively-owned infrastructures, or focussing their efforts on projects that do not rely on urban scale infrastructures. Both of these limitations would reduce the potential impact and reach of the transition initiative and also risk reducing equity of access.

23. Fossil Fuel Free Växjö, Sweden

By Gabriela Weber de Morais

Växjö, home to approximately 82,000 inhabitants, is a city in the south of Sweden. Due to the rise of oil prices in the early 1980s, biomass was added to the fuel stock used in the district heating plant, which previously was based exclusively on oil. Today almost 90% of the fuel for heating is obtained from biomass from woodchips, most being a by-product of commercial logging in the region.[216] Although the city has an environmental programme with goals to be accomplished in different fields, the main focus of its strategy is reducing carbon emissions.

To achieve its low carbon objective, the Fossil Fuel Free Växjö programme was conceived in 1996 involving public participation through the Local Agenda 21. The strategy encompasses measures related to behaviour change, energy efficiency and the transition to renewable energy in heating, power and transport. The decision to focus on carbon emissions reduction was inspired by the city's experience with the use of biomass for heating and power generation, and the significant body of relevant knowledge that had been acquired by the university and forestry sector.[217] The programme originally aimed for a 50% reduction in CO_2 emissions by 2010, and a 70% by 2025 based on 1993 emission levels.[218] Yet the municipality admits that when the 2010 goals were agreed it was not known whether they were feasible and which measures were required to meet them. The environmental programme was revised in 2010 and new goals were agreed: a 55% decrease per capita by 2015 (2059 kg) and 100% decrease per capita by 2030 based on 1993 emission levels. By 2009, the city had achieved a 34% CO_2 emission reduction per capita in relation to 1993 levels.[219]

The city has become well known for its transition from fossil fuels to renewable energy in the provision of heating. Motivated by a desire to become independent from foreign fossil fuel sources, the municipal energy company involved local companies and supported the forestry sector to develop biofuel production and combustion technology. Local actors were also assisted by the regional organisation Southeast Energy Office, which had the national government's mandate to contribute to the sustainable restructuring of local energy systems.[220] In 1980, the municipal energy company became the first in Sweden to introduce biofuels in district heating, and a cogeneration plant using renewable energy was launched two years later.[221] A new and more powerful woodchip co-generation plant was built in 1997,[222] and the municipal energy company has recently started to work with district cooling based on the use of heat instead of electricity to supply large customers.[223]

Bio-gas is now available as a vehicle fuel in Växjö (Source: Vaxjo Kommun)

The district heating system in Växjö is unique in the way it has included old buildings. District heating systems using renewable energy exist in other cities, but old buildings are seldom connected to them due to the

high costs of new piping. Between 1998 and 2005, the City of Växjö provided subsidies to citizens for the conversion of oil heating to biomass heating.[224] Even though Växjö residents have the freedom to choose their energy provider, most have opted for the local district heating provider given the renewable energy option is around 50% cheaper than oil heating.[225]

In addition to heating, the city produces 20% of the total demand for electricity using renewable sources. The rest comes from places beyond Växjö's borders and is mainly based on hydropower and nuclear power. The City of Växjö has been lobbying the national government for improvements to its power sources,[226] and measures are in place to change behaviour in order to improve energy efficiency. One example is an initiative in which clients can check their energy consumption online and see how they can save more energy and consequently also money. In recent years, state-owned companies have begun to build energy efficient wooden buildings, including Växjö's first passive houses.[227]

Mobility, which accounts for around 68% of CO_2 emissions,[228] is the next challenge. A travel survey in 2004 indicated that approximately 60% of all travels are made by car and that 50% of the car travels are shorter than 5 km. Actions undertaken by the city to increase the use of other means of transportation include the expansion of bicycle paths and other incentives to encourage bicycle use. The city has tried to reduce the impact of private motor vehicles by providing municipal subsidies to help citizens to purchase cars with lower environmental impact between 2002 and 2005, and offering free parking in the city centre to cars with lower environmental impact. A biogas plant using organic waste from households is planned to be launched in 2013. It will have the capacity to produce biogas fuel to supply the city bus fleet and for 500-1,000 vehicles.[229] The municipality recognizes that making public transport more attractive is a priority as 45% of families in Växjö don't own a car,[230] but relative to energy provision, public transport has thus far not received much attention as part of the Fossil Fuel Free Växjö programme.[231]

The city's ability to establish cooperation in several levels and mobilize resources should be highlighted. From involving NGOs and achieving consensus among politicians in the 1990s, to integrating international networks and using funds from the European Union and the national government to partly fund its initiatives,[232] Växjö has demonstrated how it could benefit from a diverse range of cooperation efforts. The city has also explored the potential of its local characteristics to design its environmental strategy. It took full advantage of its geographical location in an area with plenty of forests, where small and medium entrepreneurs were willing to partner with the local authority for mutual benefits. It helps that its background with urban sustainability dates back to 1970s when city lakes were restored.[233]

Even though the initial motivation to substitute fossil fuel for renewable energy in Växjö's heating system was more economic and political rather than environmental, it resulted in significant contribution to urban sustainability. Växjö has tested new technology and built the necessary knowledge to be one of the early adopters of a low carbon agenda. The ability to establish cooperation among different actors was essential to keep the city environmental programme and push the initiative forward. Another positive aspect is that the city report on progress also exposes the shortfalls – not always a common practice. Most of the achievements in Växjö thus far have been

based on changing from fossil fuels to renewable energy and improvements in efficiency rather than reducing energy demand in absolute terms. Reducing fossil fuel usage in the transport sector is likely to be the city's biggest challenge. If the focus is on reducing CO_2 emissions per capita at the expense of broader improvements to urban sustainability, or if fuel switching is pursued instead of reducing car use, rebound effects may limit the city's ability to effectively decouple itself from fossil fuels.

24. Strengthening food security in Buenos Aires, Argentina

By Dr. Walter Alberto Pengue (Peri-urban Institute, Universidad Nacional de General Sarmiento) with contributions from Dr. Ana Carolina Herrero (UNGS and National Team of ProHuerta INTA)

Spurred by recurring shortages in food, economic crises and limited access to productive land, recent years have seen the increased implementation of projects that help to promote food production within cities and along their peripheries. According to the Food and Agriculture Organization, nearly 800 million people are involved in the production of food in cities around the world, 150 million of whom are employed full time. Cities like those in Cuba have shown that organic farming methods can provide a low-cost means of producing food, and in addition to meeting the nutritional requirements of city dwellers, urban agriculture opens up opportunities for cities to derive economic benefits from exporting surplus food to surrounding areas.

One of the most influential urban and peri-urban food production programs is Argentina's ProHuerta, funded by national government with support from international organisations. Started by the Instituto Nacional de Tecnología Agropecuaria (INTA) in the 1990s, the program has helped millions of people to produce their own food, and has grown steadily over the years. Today, ProHuerta supports 500,000 urban gardens, 7,000 school gardens and 4,000 community gardens, reaching a population of over 3 million people around the country. The program incorporates over 3,600 villages, as well as larger cities like Rosario, Mar del Plata and Buenos Aires. Over 80,000 metric tonnes of food is produced by 4000 ha of orchards nationwide, with a market value of around 150 million Argentine Pesos (approximately 30 million US Dollars[234]).[235] Each Peso invested by ProHuerta generates approximately 10 times its value in food, not to mention numerous non-monetary benefits associated with providing the poor with an opportunity to earn money whilst contributing positively to society.

ProHuerta aims to improve nutrition amongst impoverished peri-urban and rural populations by encouraging the production of organic food on a small scale (from home gardens and small farms to schools, institutions and community organizations). In the Buenos Aires Metropolitan area, a team of 60 field technicians and 1,740 'promoters' have been trained to teach organic food production techniques and act as intermediaries between ProHuerta and the urban gardeners. They also facilitate the distribution of inputs required for food production such as free seeds, cuttings, chickens, rabbits and tools provided by ProHuerta. The use of agrochemicals is avoided, and the promoters educate urban gardeners on natural methods of pest and disease control which help them to save money.

Bonpland Market, Buenos Aires (Source: Communitary Bonpland Market, 2009)

The promoters train urban gardeners in the preparation of the land for food, and the construction of tools for small scale farming. Food produced in home gardens and orchards is typically consumed by the farmers' families, and community gardens serve those who do not have outdoor space at home. Home gardens of around 100 m^2 are suitable for feeding families, but schools require around 200 m^2 and community gardens are closer to 1,000 m^2 in size. The average annual production of a family garden is over 200 kg of fresh vegetables, which can feed a family of five. Some gardens are also able to supply eggs and meat from chickens and rabbits.[236]

ProHuerta's approach to food self-sufficiency offered an ideal solution to the 2001 food crisis for the city of Buenos Aires, particularly in the poor areas where the effects was most harshly felt. Local production of fresh fruit and vegetables helped to address issues of malnutrition amongst the poor whilst indirectly providing economic, social and environmental benefits.[237] The technical team of AMBA ProHuerta now services most of the city, coordinating a network of 1876 promoters consisting mainly of volunteers and teachers. It works with over 200 organizations and institutions to deliver inputs and provide technical support and training, and 323,559 people are now involved in producing food under the program at a network of 50,362 urban gardens and 1048 small farms, which also provide chickens and rabbits.

While the program was initially intended to address the food crisis and malnutrition amongst the city's poor, bartering and trading at community fairs has provided an additional benefit in the form of strengthened social cohesion in Greater Buenos Aires.[238] Many of these food fairs are held more than once a week, with fruit and vegetables being the main items traded. They have helped to stimulate local economies and have provided new employment opportunities for the poor. In some cases, municipalities have recognised the value offered by these fairs and have dedicated municipal land for use as market places.

In addition to the health, social and economic benefits, the ecological advantages of ProHuerta's organic approach to urban food production are numerous. By growing food in close proximity to consumers and using local natural resources, the beneficial ecosystem services provided by plants can be incorporated into city spaces and the ecological footprints of city dwellers can be reduced.[239] By increasing biomass production and re-circulating flows of organic waste, materials, water and energy within the city,[240] more sustainable urban environments can be created.[241]

The accumulation of nutrients in city spaces as a result of human activity makes many of the world's urban and peri-urban areas suitable for food production. Promoting agro-ecological methods of food production and extending assistance to the urban poor can be used to build food security and allow the poor to enter the economy through entrepreneurial micro-enterprises. Local governments have an important role to play in freeing up open land for farming or markets and supporting initiatives like ProHuerta that educate and support the poor in their efforts to improve their lives. As oil prices drive up the cost of food, such initiatives are likely to become more relevant to cities in both the developing and developed world.

25. Energy-Efficient Housing Upgrades for the Poor in Cape Town, South Africa

By Natalie Mayer

Socio-economic upliftment and climate change mitigation come together in Kuyasa, Africa's first clean development mechanism (CDM) project and the world's first Gold Standard CDM project. The initiative is heralded for the mass roll-out of sustainable energy installations to low-income households, and the active engagement of the community.

Motivation and goals

Social needs and ecological pressures have converged to spur the development of the Kuyasa CDM project in Cape Town, South Africa. The dwellings at Kuyasa were built by government under the Reconstruction and Development Programme (RDP) to house people moved from shacks in the Khayelitsha.[242] Although they provide an improvement in living conditions, RDP houses are energy inefficient. This makes them stiflingly hot in summer while cold and damp in winter, increasing the need for heating and cooling and impacting on residents' health.[243] Poor and unemployed beneficiaries are often unable to afford energy services such as lighting and hot water which contribute to socio-economic development.[245] Meeting these energy needs via conventional methods was problematic for the City of Cape Town due to financial, ecological and energy supply constraints, so an innovative approach to the problem was required.

The goal of the Kuyasa project was to provide low-cost, efficient energy services and thermal comfort to individual low-income households[246] as a means of improving quality of life for the poor in a manner compatible with the city's commitment to reducing reliance on coal-fired electricity.[247]

At the same time, the project was to provide sustainable employment and skills development opportunities for the local community.[248] This was to be achieved by installing insulated ceilings, solar water heaters (SWHs) and energy-efficient lighting in 2,309 homes in Kuyasa. Community ownership was recognised as a key ingredient for success, so the project was designed to focus on this from planning through to implementation.[249]

Practical implementation and benefits

After three years of planning in partnership with SouthSouthNorth (a non-profit organisation delivering community-based climate mitigation projects) and the beneficiary community,[250] the City of Cape Town registered Kuyasa as a CDM project in 2005. A business plan by the South African Export Development Fund (SAEDF) allowed SWH installations to begin in 2008.[241] The SAEDF has underwritten the project, and oversees it with the help of a Kuyasa resident manager.[252]

The cost of the project to date has been approximately R36 million (approximately US$4 million[251]).[253] Funding came primarily from the Provincial Department of Housing, assisted by the Department of Environmental Affairs and Tourism and ICLEI Local Governments for Sustainability[254] with the balance from the SAEDF.[255]

A conventional approach to the provision of energy services could not have offered the sustainable development benefits of the Kuyasa project. The use of energy-efficient light bulbs, insulated ceilings and SWHs has reduced household electricity requirements, and thus the carbon dioxide emissions and climate impact associated with daily life. Households save on the cost of energy services, while enjoying the health benefits of an insulated home.[256] The community's involvement in the installation and maintenance of these interventions has provided skills development and sustainable employment opportunities to Kuyasa residents, rather than the usual outsourced 'install-and-go' approach. As a CDM project, income can be derived from the sale of carbon reduction certificates (CERs) to expand installations and employ local residents to provide maintenance to SWHs on a long-term basis.[257]

Contribution to urban sustainability

CDM projects are required to produce quarterly monitoring reports by the United Nations Framework Convention on Climate Change.[258] In addition to these evaluations, a sample baseline survey of 2,000 households was conducted in 2008, with a follow-up survey of 700 households in 2009.[258] The survey noted the following socio-economic and ecological improvements:[260]

- On average, R150 (approximately US$16) was saved per month per household in winter as residents were buying less electricity and paraffin;
- The frequency of respiratory illness such as pulmonary pneumonia and tuberculosis was found to have decreased in 76% of households surveyed, due to better insulation and a reduction in paraffin use;
- 87 jobs had been created in the working team;

- Hygiene had improved with the availability of piped hot water;
- The equivalent of 6,580 tons of carbon was saved each year through the decrease in fossil fuel use and greater reliance on renewable energy;
- The switch from imported SWHs to locally-made models has helped to build the local economy and create jobs

Successes and failures

Critical to the success of the project has been the community's acceptance and engagement with the energy service installations. From the planning stage, the community was actively included in the project and was able to give input.[261] The creation of sustainable ceiling and SWH businesses and tour guiding work, as well as the small monthly levy paid by each household, sees community members personally invested in the project. There is a marked pride in the development, and a belief that it has brought the people dignity.[262] The ongoing educational support and training of workers, and access to a project manager on-site in Kuyasa have also been valuable contributors to success.

The project's challenges have predominantly been financial, with a lack of available capital and low priority in the spending of public finance.[263] Although accumulating approximately R1 million (approximately US$113,000) worth of carbon reduction certificates (CERs) per year, the project has not yet sold any CERs, preferring to wait for a better Euro-Rand exchange rate and an increase in demand for the certificates to improve financial gains.[264] However, the implementation of a creative financing model utilising the CDM has perhaps been the project's most significant success. In future, the model will be used by the proposed National Sustainable Settlements Facility (NSSF) to give developers access to carbon funds to cover the additional costs of installing and maintaining efficient energy services in all subsidised housing.[265]

Though socio-economic development goals are being reached successfully, the ecological impact to date has been limited. Winkler points out that carbon emission reductions for the Kuyasa project will be relatively small, totalling just under 365,000 t over 21 years for Phase 1 (2,309 households) and Phase 2 (4,000 households) of the project combined.[266] However, should this pilot project blossom into a public programme through the NSSF, carbon emission reductions could be in the region of 6 million t per year.[267]

Conclusion

The daily lives of Kuyasa residents have been improved by the CDM project. Their strong sense of ownership and responsibility for the installations has been critical to its success, and the considered inclusion of the community from the very beginning has encouraged them to actively invest their time and money in the project. The broader impact on the design policy for low-income housing has the potential to spread the socio-economic and ecological benefits to other areas of South Africa.

26. The politics of sustainable water management in Chennai, India

By Matthew Wood-Hill (Development Planning Unit, University College London)

The acute water crisis experienced in Chennai, the capital of the state of Tamil Nadu, India, in 2003-2004 demanded a revised strategy with a longer-term vision for a more sustainable approach to water management in the city. Though pre-colonial Chennai was supplied by a rainwater-fed system made up of a series of tanks, reservoirs, lakes, and ponds, the more recent history of water provision to the city has relied on 'macro' systems of water supply. In the nineteenth century these functions were performed by two reservoirs, with water sourced via underground pipes. When the expanding city experienced its first major water crisis, in the 1960s, the institutional response was to attempt to pipe water from the Veeranam dam, some 225 km away. That this project was deemed a failure after just a few years did not deter the state from pursuing such mega-engineering projects: the Telugu Ganga project aimed to channel water from the Krishna River in the neighbouring state of Andhra Pradesh. Though this was commissioned in the mid-1970s, work only began in 1983, and was not completed until 1997, providing much less than the promised volume of drinking water to the city.

Rainwater harvesting, in the context of the 2003-2004 crisis, offered a means of breaking away from this dominant approach based around large-scale solutions, by providing something local, tangible, and relatively inexpensive. Its primary goal, rather than increasing the immediate availability of surface water (with over 40% estimated to be lost due to evaporation or seepage), was to replenishing Chennai's depleted aquifers, thus providing a sustainable, reliable source of water.[268] The technique had been increasingly promoted by MetroWater (the municipal water authority) since the early 1990s. In October 2002, the Municipal Administration and state Water Supply Department passed an order demanding that all buildings in the city be capable of harvesting rainwater before September of the following year.[269] The adoption of this practice as the preferred means of tackling the crisis, over long distance water piping and desalination plants, therefore seemed natural.

In addition to the ecological and economic benefits of the scheme, it also promised to strengthen the essence of democracy by creating the foundations for partnerships between state, civil society and community actors, across class and caste divides. In the neighbourhood of Thiruvanmiyur, in the southern Chennai, these social benefits were tested as the community-led *Puduvellam* (meaning 'New Water') initiative, aligned with the plans laid out by the Indian National Trust for Art and Cultural Heritage (INTACH), sought to restore the presently-defunct historic Marundeeswarar temple tank as a means of groundwater recharge.

Numerous unsuccessful attempts had been made to create a public-private partnership to resurrect the tank over previous decades. *Puduvellam*, led by a member of the predominantly middle-class Valmiki Nagar community, attempted to engage residents associations in the area to foster community support for the project through awareness and fund raising events such as community festivals around the temple tank. This suggested a further benefit of the project, and a goal of INTACH: to reclaim public space and to cultivate community cohesion. The purpose of such

awareness-raising activities was to stimulate a voluntary spirit, so that members of the community, irrespective of class or values might come together to help clean out the tank. Here the efforts to appeal across class and caste boundaries can be seen to have backfired: despite the origins of the leader of the *Puduvellam* initiative, he could not successfully engage other middle-class residents who were reluctant to 'muck in' with those of a lesser social standing, and instead came to view *Puduvellam* as a charitable cause. Instead of taking ownership of the project, the middle class separated themselves as an influential external group who employed the poor to clean the tank, but did not partner with them to build social cohesion between the classes.

The Marundeeswarar Temple Tank, Thiruvanmiyur, Chennai following restoration and the installation of barricades (Source: Pushpa Arabindoo, 2011)

The objective of the project – as a means of groundwater recharge – became confused with efforts to beautify the area through the removal of encroachments and regeneration of the tank and its surroundings. In spite of this apparent change in focus, *Puduvellam*'s vision of stormwater drains redirecting water into a clean, functional tank was realised. Although its potential may not have been maximised, the temple tank contributed to the environmental sustainability of the area by harnessing the rains as a means of sustaining the level of the water table. Issues of social justice, however, were largely ignored as middle-class residents continued to access water through private bore wells which adversely affected groundwater supplies and reduced the yields of other wells across the metropolis.[270] The poorer communities experienced a further injustice as barricades were erected around the tank once work was completed, also depriving INTACH of its vision of the area as a democratic space.

As the crisis abated, momentum for the project slowed. A conclusive evaluation of the success of the *Puduvellam* initiative, or indeed rainwater harvesting across Chennai has been near impossible. The Indian Ocean Tsunami in December 2004, followed by intense flooding as a result of the northeast monsoons in 2005 changed the focus of discussions. More recently, attempts have been made to resuscitate the temple tank with varying degrees of success, but the opening of the Minjur

desalination plant in northern Chennai in 2010 illustrates how mega-infrastructure solutions are favoured over simple, decentralised approaches to augmenting the water supply.[271]

Overall the *Puduvellam* initiative was a success in promoting rainwater harvesting as a low-technology solution through the reuse and restoration of pre-colonial infrastructure to recharge the city's depleted aquifers. In merging an ecological agenda with a matter of local culture and history, *Puduvellam* was able to capture popular support. However this did not translate into action and this underlines the importance of properly communicating and promoting the message of partnership and co-operation. Above all the case shows how prevailing social conditions resulting from the traditional class/caste structure could not be overcome, even when the initiative emerged from within the middle-class community.

The middle-class residents, with a higher regard for more prestigious technological solutions, could have made the project work but their apathy was decisive.[272] Without sufficient access to water wells, and denied access to the temple tank once restored, the poorer communities – those with the greatest need – gained least from the eventual solution. The desalination plant has broadened the gap between water as a commodity and water as a basic right, arguably leaving Chennai's lower-income residents yet further adrift.[273] Above all, the case exemplifies the difficulties in bridging the green and brown agendas, and how without the awareness and support of key stakeholders and interest groups they can impede one another.

27. Incentivised recycling in Curitiba, Brazil[274]

By Oscar Ricardo Schmeiske (GIS Co-ordinator, Instituto de Pesquisa e Planejamento Urbano de Curitiba)

The city of Curitiba in southern Brazil has become famous for its achievements in urban planning, and is often considered to be a model of urban sustainability for developing countries. Its long-term planning policy and well-known interventions in public transport and environmental protection have helped the city to achieve a high quality of life for its citizens at a relatively low cost, allowing it to grow in a sustainable direction.

Some of Curitiba's most remarkable successes are its solid waste management and recycling programs. Population growth rates of 5.34% per year during the 1970s combined with changes in consumption patterns resulted in a higher proportion of non-organic waste being generated than ever before and a much faster depletion of the city's landfill capacity. In response to this, the city of Curitiba started the first recycling program in Brazil's large cities in 1984, which turned out to be one of the most successful in the world and a leading example of a low cost but effective waste management program.

The recycling program - loosely translated as "Garbage that is not Garbage" (*Lixoquenão é lixo*) - was based on encouraging home separation of garbage into organic and non-organic components. Recyclable waste was collected once a week by a private contractor, and taken to a processing centre owned by the city. The facility employs homeless people and recovering alcoholics to sort the garbage into different types of materials that are sold on to recycling factories.

Extensive publicity and education campaigns were used to encourage residents to separate their garbage, with a strong focus on the role of children as change agents. Several communication campaigns were aimed specifically at encouraging children to separate their waste at home, mainly through the city's elementary schools. A cartoon family known as the Leaves (*Família Folhas*) enacted common household scenarios in comics and plays, and the campaign was designed to be fun and child-friendly. Young students were very effective in disseminating ecological concepts to their families and making sure that their parents participated in domestic garbage separation. The city has since also included children in a water conservation programme, teaching them how to test water for pollution so that they may have a greater appreciation for it.

As in many cities in Latin America, shantytowns and squatter settlements in Curitiba form high density settlements in vulnerable areas such as hillsides and flood plains. The uncontrolled dumping of garbage in these areas soon started to affect watercourses, resulting in flooding and the spread of disease. It is often difficult to extend conventional mechanized methods of solid waste removal to these areas due to irregular alleyways and the interference of criminal elements. Formal waste collection in Curitiba also faced resistance from autonomous garbage and recycling collectors whose livelihoods were threatened by municipal collections.

In response to these challenges, the city created the "Garbage Purchase" program. This was aimed at encouraging neighbourhood associations to become involved in the management of centralised garbage containers on the periphery of areas that are difficult for collection trucks to access. Residents associations work with the city government to distribute bags and control the recyclables collected by each family. To incentivise the public to get involved, every bag filled with 8 to 10 kg of waste could be exchanged for a bus ticket. The value of these tickets was equivalent to the cost of conventional garbage collection, but did not involve any direct expense by the city as bus operator companies are remunerated based on mileage and not passenger numbers.

Recyclers receiving fresh fruit and vegetables in exchange for recyclables (Source: IPPUC 2011)

Following initial success, an undesirable side effect of this approach became apparent when informal collectors started to encroach on areas serviced by formal collections. Formal collection soon became unprofitable because the domestic waste was removed before the trucks had a chance to collect it. In addition, the informal collectors' carts started causing traffic problems as they made their way around the city without adhering to the rules of the road or safety protocols.

In the wake of an outbreak of cholera in Brazil in 1991, the consumption of vegetables dropped sharply and there was a surplus of agricultural products in the city's green belt. To capitalise on this opportunity, a program called "Green Exchange" (*Câmbio Verde*) was started to ensure that this food did not go to waste. The city now buys food items from regional producers at a reasonably low price, and distributes it to recycling collectors at a number of distribution points around the city. Initial tests were a great success, and the Green Exchange has now become a permanent program in Curitiba with over 80 distribution points around the city. Currently, every 4 kg of recyclable materials can be traded for 1 kg of locally cultivated seasonal produce, improving access to healthy food for the poor whilst tidying up the city.

The waste management programs established in Curitiba have helped to promote a better quality of life for people living in shantytown communities and small agro-producers. In addition to improved garbage collection in areas that are difficult to access by road, the poor have benefited from improved diets and small local farmers have benefited from more stable demand for their agricultural produce. The city's recycling initiatives have extended the life time of its landfill by diverting 2,400 m^3 of recyclables each day – which represents around 25% of daily production of garbage. In the year of 2010, the regular collection of recyclables by trucks amounted to around 21,800 t, and the Green Exchange program a little more than 2500 t. The largest part of the recyclables collection – 190,000 t – was carried out by Informal collectors. Part of the revenue acquired from the recyclables is used for the maintenance of the collection process and for research, but most of it goes to *Instituto Pro Cidadania de Curitiba*, a Non-Governmental Organization which operates the city processing centre and promotes citizenship.

28. Socialisation of solid waste management in Ho Chi Minh City, Vietnam

By Dr. Apiwat Ratanawaraha (Department of Urban and Regional Planning, Chulalongkorn University)

'Socialisation of solid waste management,' as the term is used in Vietnam, indicates the active participation of community groups, cooperatives and independent collectors in managing urban solid waste systems. As Vietnam experiences rapid economic growth and a burgeoning urban population, there is an increasing amount of solid waste being generated each day in its major cities, especially in Hanoi and Ho Chi Minh City. Not only household but also industrial and medical hazardous waste is degrading urban liveability and sustainability. Uncollected solid waste poses great threats to the quality of surface and ground water, and creates health hazards to the community. The negative effects are particularly severe in areas where solid waste collection is not adequate, especially in low-income settlements and peri-urban areas where the poor live.

About nine out of ten of the poorest households in Vietnamese cities do not have access to organised solid waste collection services. The government does not have sufficient financial, technical, and human resources to expand formal collection services to cover all areas, and public awareness is

lacking about the importance of waste removal before collection. Waste collection in Ho Chi Minh City also faces physical limitations because almost three-quarters of households are located in narrow alleys that are inaccessible to large vehicles.

Community groups and co-operatives are now working with the local authorities to fill the gaps in waste collection services as a part of the Vietnamese government's policy on socialization of environmental protection. Several cities are promoting community programs on waste collection in which community groups, cooperatives, and syndicates of individual collectors are responsible for collection activities. The Hanoi People's Committee has authorized a socialization program for waste collection since the 1990s. Local community groups now assume responsibility for hiring waste collectors, purchasing collection equipment, collecting fees, and overall management of the collection system. Members of the Vietnam Women's Union have also played key roles as both managers and collectors.

The aim of the socialization programs is to promote community participation in solid waste management. It is hoped that the communities contribute more financially to recover the cost of collection, transportation and treatment of solid waste, and share the responsibility for environmental sanitation work. Community organizations also mobilize the residents to collect and separate their waste and to collect litter in public spaces.

Two systems for solid waste collection work alongside each other in Ho Chi Minh City. The 'formal' system is in charge of street cleansing and collection of waste in markets, offices and public buildings. This system also collects wastes from households located along main roads, which account for about 30% of total households. At the same time, the 'informal' system includes individual waste collectors, their syndicates, and environment sanitation cooperatives. The informal sector collects waste from households located in small alleys, and transports it to intermediary depots where it is collected by waste transport agencies.

Syndicates of individual collectors play a critical role in managing the informal system. Such syndicates are social organizations in which individual collectors participate on a voluntary basis. To become a syndicate member, each collector submits an application and pays a monthly fee for use of the depot, general administration, and a fee for cost-recovery that is transferred to the public waste agency. The syndicates actively discuss with the local authority the areas that require additional services, and quickly mobilize members to cover those areas once they gain permission from the authority. The syndicates also handle problems and conflicts that arise in the collection process.

Ho Chi Minh City's 3,000 independent collectors are well suited to collecting waste from the narrow streets where vehicles are unable to drive. By using low-skilled workers instead of expensive machinery to collect waste, this community-based system shows that waste collection can contribute to improving urban liveability and sustainability with fewer resources and less impact on the environment. The benefits of the city's approach to waste collection can be summarised as follows:

- *Wide and efficient coverage:* The system proves to be effective in removing the daily waste discharged of from households in small alleys and communal buildings. In some districts of Ho Chi Minh City, waste from up to 90% of households is collected by the individual collectors.

- *Appropriate technologies:* Despite being rudimentary and apparently not hygienic, the equipment and tools are cheap to manufacture and operate. The design is simple and well adapted to local characteristics. Tricycle carts and three-wheel auto-rickshaws are easy to manoeuvre through the small alleys of the city.

Solid waste collection by motor tricycle (Source: Dr. Pham Gia Tran)

- *Employment generation:* The business provides employment to poor individuals who lack the skills necessary for more demanding enterprises.
- *User-pays system:* The door-to-door collection is a reliable system that serves most households. This promotes an efficient user-pays system, as people are more willing to pay when the services are more reliable and effective. The collection fees are negotiated between households and collectors according to affordability and willingness to pay.
- *Demand responsive:* The syndicates mobilize services in areas not covered by the public agency. They actively reach out to households in need of service.
- *Cost effective:* The collection services currently provided by syndicates of individual collectors are cost effective. If they were to become district employees, the payment of salaries and provision of equipment would require an enormous budget beyond the government's financial capacity.

Despite its successes, the socialisation of waste management in Ho Chi Minh City still faces several challenges:

- No concrete mechanisms and legislative documents are in place for operation.
- No regulations compel residents to participate in maintaining sanitary environments or ensure that their waste is removed. Many households have no waste collection contracts and avoid paying collection fees, so illegal dumping represents a challenge.
- Socialisation is currently limited to the collection component of the solid waste system. It is difficult to socialise the transportation and treatment components due to high equipment costs and a lack of space for secondary collection and transportation.
- Health and safety concerns for the collectors are lacking.

Urban social infrastructure programs can be sustainable and successful if local communities and small independent service providers are involved as major stakeholders and decision-makers. Each stakeholder plays distinct and important roles. As different actors may have different interests and potentials, the negotiation and coordination over roles and types of involvement is a crucial element in organizing the scheme. Managing waste collection and transportation is not only the

responsibility of the local authority, but should be shared by multiple parties. This case study shows that communities are capable of adequate waste management and can play an important role in assisting infrastructure service providerswith consumer participation or by participating in monitoring and evaluation. Under certain conditions, small, independent collectors could be more efficient in service provision than more conventional, centralised approaches to solid waste management.

29. 100% biogas-fuelled public transport in Linköping, Sweden

By Natalie Mayer

Sweden's interest in renewable fuels began after the oil crisis of the 1970s, which led to a massive hike in fuel prices. The country drew up plans for a natural gas pipeline that would run near Linköping, stimulating talk of the possibility of methane exports. Worsening urban air quality from vehicle emissions required swift intervention, and the development of gas as an alternative fuel for Linköping's public buses was identified as an opportunity to address rising costs and environmental issues simultaneously.[276]

Emissions from diesel buses were causing smog and soot to cover the city.[277] Leaders came together to discuss how to clean up the environment, while transforming the area and boosting the local economy.[278] The city opted for buses powered by natural gas, which could be supplied via the proposed pipeline.[279] However, plans for the pipeline later fell through due to financial concerns.[280] Still enamored by the potential of gas, the city decided that the public transport system should run on locally-produced biogas.[281] The fuel is suitable for the city context as it can easily be collected from wastewater treatment plants and landfills. Additionally, it doesn't need extensive fuelling infrastructure, which means it can be introduced in stages and doesn't require as significant an investment.[282]

The main objective of the initiative was to reduce the pollution caused by public transport and provide a high quality environment for the citizens of Linköping.[283] Key aims were to develop an integrated system to turn waste into biogas which would connect rural and urban areas and fuel city buses.[284] It was envisaged that over a number of years, the entire bus fleet would be replaced by bio-methane buses.[285]

Implementing the biogas transport system

In 1991, TekniskaVerken (TVAB), the municipal services provider, set up a pilot project of 5 buses powered by methane collected from the city's wastewater treatment plant.[286] Close collaboration between TVAB and Linköping University helped to speed up the development of biogas knowledge and production.[287] Project evaluation revealed that the wastewater treatment plant would be unable to provide sufficient methane to power the entire bus fleet. It concluded that a separate production plant should be built to control the input of feedstock and increase the output of biogas.[288]

The source of feedstock was then expanded to include waste from the local slaughterhouse owned by Scan-Farmek. The Federation of Swedish Farmers (LRF) also came on board to supply feedstock in the form of crop residues and manure.[289] LRF agreed to purchase the digested residue (a by-product of the methane manufacturing process) for use as a valuable fertilizer.[290] To solidify their co-operation, the three stakeholders started an associated company with shared ownership called Linköping Biogas AB (now Svensk Biogas) in 1995. The company received government funding to build a €140,000 (US$183,000) methane production facility, completed in 1996.[291] The plant can treat 100,000 t of waste per year, and produces 4.7 million m^3 of upgraded biogas per year.[292] The newness of the biogas concept made it too risky for the city to shoulder the financial and intellectual burden alone, so additional funding and expertise came from the municipality of Linköping, the county, the regional bus authority, LITA and TVAB.[293]

The overhaul of the city's public transport system began in earnest in 1997, when 27 buses were replaced.[294] In 2001, the sources of feedstock were again expanded to include waste from local restaurants. By 2002, all buses in the fleet were bio-methane driven, and in 2005 the world's first biogas train became operational in Linköping.[295]

Impact on resource flows in Linköping

The transition from a fossil-fuel driven public transport system to one powered by biogas has improved more than just air quality in the city.[296] The use of biogas for fuel produces very few hazardous emissions and greenhouse gases.[297] The biogas from the plant replaces about 5.5 million litres of petrol and diesel each year, decreasing the need to import fossil fuels substantially.[298] Carbon dioxide emissions have been reduced by more than 9,000 t per year since 2002, lessening the city's contribution to global warming.[299]

The production of biogas turns waste products into a valuable resource, thereby reducing the need for environmentally-destructive landfills and waste incinerators, and creating circular rather than linear resource flows through the city.[300] Specifically, the project has cut the volume of waste sent for incineration in Linköping by 3,422 t annually.[301] A by-product of the biogas processis biological fertiliser, which is purchased by the farmers' association to replace energy-intensive, fossil-fuel based fertilisers. Because bio-fertilisers are made from waste products, nutrients such as phosphorus are able to cycle through the economy, returning to nourish farmlands rather than accumulating in toxic concentrations at landfills.[302]

The project has also contributed positively to the city's economy. Including local farmers in the production of biogas and sale of bio-fertilisers has increased their competitiveness and kept financial flows within the local economy.[303]

Factors aiding and limiting success

It would not have been possible to implement such a novel project if it hadn't received strong political support.[304] Long-term co-operation between the city, farmers' association, Linköping University, transit authorities, and other actors has arguably been the most significant factor contributing to success.[305] Stakeholders were involved early on in the project, and were allowed to make important

decisions and raise difficult questions, encouraging their commitment.[306] This involvement was so extensive as to be thought of as co-design. Most of the people involved were from the region, and were well acquainted with Linköping's ecological, social and economic situation. Sufficient funds and a good measure of courage amongst decision-makers also helped the project come to fruition.[307]

Despite strong political and social support, the project faced several challenges. Biogas production in Linköping was not considered profitable enough, so the company decided to expand regionally and also to supply to the private transport market.[308] The decision to expand was not unanimous, however, and Scan-Farmek and LRF sold their shares in the company to TVAB, which became the sole owner.[309] A focus on large-scale production plants meant that the opportunity to include small-scale biogas plants connected to a biogas grid was missed. This could have allowed greater coverage, reduced material handling costs and stimulated local economic development.[310] Although the project is a leading example of the ambitious use of renewable energy in the transport industry, infrastructure issues, vehicle limitations, and legislation continue to limit biogas development in the region.[311]

Conclusion

The transition to a biogas public transport system has improved air quality for the citizens of Linköping. Co-operation between the city and local industries has helped to reduce waste and produce renewable fuel, while supporting local agriculture. The potential for a biogas grid powered by city waste products and the inclusion of smaller-scale production plants present significant opportunities for the expansion of sustainable transport in the city region.

30. Replacing Highways with Rivers: the Cheonggyecheon River Restoration Project in Seoul, Republic of Korea

By Natalie Mayer

Between 2003 and 2005, an elevated highway covering Seoul's Cheonggyecheon River was demolished to improve the area's environmental and aesthetic condition. Now a city highlight visited by 90,000 pedestrians daily, the restored river is a model for urban renewal projects worldwide. Throughout much of Seoul's history, the Cheonggyecheon has been a polluted river prone to frequent flooding, particularly after the deforestation of the surrounding area to fuel economic development.[312] The response was to cover the problem, turning it into an arterial road in 1961.[313] The rapid urbanisation that followed prompted the building of an elevated highway above the covered river, completed in 1971.[314]

In 2000, the Korean Society of Civil Engineering found that the road and elevated highway had severe structural problems that would cost approximately US$95 million to fix.[315] In addition, downtown Seoul was experiencing serious traffic congestion and poor air quality from the mass use of private vehicles, while public transport was in need of a thorough upgrade.[316] Urban ecosystems had

suffered considerable degradation during fast-paced industrialisation and urbanisation, and the city lacked green spaces for public recreation.[317] There was also concern about socio-economic inequality: while development had taken place on the south side of the Cheonggyecheon, the north side had become uncompetitive and dilapidated.[318]

Rather than repair the highway, the Seoul Metropolitan Government decided to restore the river, using it as an opportunity to address several of these problems at once.[319] The restoration project was thus intended to recover the flow of the river, to reintroduce biodiversity to the area, and create a space where people and nature could interact.[320] The project would also rehabilitate significant historical and cultural sites, and create a centre for business and finance, uplifting the area while restoring the balance of development between north and south Seoul.[321] Designers intended it to be a symbol of the city's '21st Century Advanced Era' identity.[322] The project entailed demolishing the highway, restoring the river, and creating a 5.84 km park on either side totalling about 1,000 ac.[323]

Project implementation

The project began in July 2003 and was completed in October 2005. It cost Seoul US$367 million, and social costs were valued at US$1,900 million – but the project is expected to deliver US$3,500 million worth of social benefits.[324]

The river was restored in three sections, differentiated by urban, urban-natural, and natural landscaping areas.[325] Curves and irregularities in the river provide suitable conditions for fish, and swamp areas offer a habitat for wildlife. An ecological park and continuous green belt encourages human interaction with nature.[326] Two of the old historical bridges, the Gwanggyo and the Supyogyo, have been restored,[327] and traditional cultural activities such as the lantern festival and bridge stepping on Supyogyo Bridge are being revived.[328] The project design promotes walking and cycling, while traffic flow to the city centre was improved through one-way roads and designated bus-only lanes.[329] The bus service was upgraded through a switch to travel cards for payment, a centralised logistics control system and an effective transfer system between main routes and feeder routes. Hours of operation were extended and service frequency increased to make the service more useful. Similar improvements were also made to the subway. The city has discouraged parking in the central area by raising parking fees and clamping down on illegal parking, whilst running campaigns to encourage commuters to leave their cars at home for one day a week.

The project was led by Seoul Metropolitan Government, championed by Lee Myung-Bak, Seoul's mayor at the time.[330] The planning and execution of the project was the collective effort of the Implementation Centre (part of the Seoul Metropolitan Government), the Citizens' Committee, and the Research Support Group from the Seoul Development Institute (sponsored by the Seoul Metropolitan Government).[331]

Contribution to urban sustainability

Social sustainability has been improved through an increase in quality of life: citizens now have green public spaces where they can meet socially, exercise, participate in traditional festivals and enjoy cultural events. The project inspired the creation of an informal 'knowledge community' to

The Cheonggyecheon after restoration (Source: Volker Lee (http://www.panoramio.com/photo/12155043))

discuss issues relating to the Cheonggyecheonand recommend solutions.[332] The public now have access to valuable educational resources through their renewed contact with nature, restored historical sites, and the Cheonggyecheon Museum.[333]

Ecological sustainability has also improved. Fossil fuel use has been reduced by removing about 170,000 cars from the artery each day, improving public transport, and creating pleasant pedestrian routes to encourage walking.[334] This has also led to reduced air and noise pollution in the city.[335] Specifically, small-particle air pollution in the area has fallen from 74 to 48 mcg per m^3.[336] High city temperatures have decreased by up to 5˚C due to reduced traffic, the proximity of cool water, and a 50% increase in average wind speeds following the removal of the highway.[337] The restoration has re-established lost habitats, and as a result the number of fish species has increased from 4 to 25, bird species from 6 to 36, and insect species from 15 to 192.[338] The river has also helped to improve Seoul's resilience to climate change as the open river is better able to cope with flooding than buried sewers.[339]

Economic benefits can be seen in an increase in the number of businesses and employment density within 1.2 km of the Cheonggyecheon corridor.[340] Property prices have also increased at double the rates found elsewhere in the city.[341] Single-family residential units are now more likely to convert to high-rise residential, commercial-retail, and mixed units.[342]

Lessons from the project

Though the lack of private sector and NGO involvement may be seen as an 'imbalance of power' in other contexts, the Seoul Metropolitan Government's dominant role (and the championing of the project by the then-mayor, Lee Myung-bak) was key to the project's success. As a result, restoration plans were coherent and achieved a significant level of integration. Implementation time was also relatively short, due to fewer administrative challenges. Also contributing to success were the strong ties and shared agenda of the Metropolitan Government, Cheonggyecheon Citizens Committee and the Research Support Group during planning.

Despite its overwhelming success, a few criticisms have been made of the project. Those with visual impairments and mobility problems complained that they had difficulty accessing the stream.[343] Lifts and free wheelchairs were subsequently provided at seven locations, but the minority feel indignant that their needs were not included at the design stage.[344] Some have criticised the project's ecological authenticity and cost, given that water must be pumped from a nearby river and groundwater reserves to keep the Cheonggyecheon flowing all year round.[345] These critics have called for a more expansive ecological and historical restoration that includes the entire Cheonggyecheon basin and ecological system.[346] Finally, rising property prices due to the urban renewal have caused concern that local inhabitants may soon be unable to afford the cost of living and working in the area.[347]

Conclusion

The success of the Cheonggyecheon river restoration project and the pleasure it has provided to Seoul's citizens has inspired similar projects around the world.[348] Cities in Japan, Singapore and the United States are recovering streams from storm drains, acknowledging the significant contribution of a well planned urban green belt to social, ecological and economic sustainability.[349]

References

1. Shirazi, B. (2004) Integral Education: Founding vision and principles. Integral Review, (7)1:4-10.

2. Barnard, A. (2005) The religious philosophy of consciousness of Sri Aurobindo. PhD. Thesis. University of South Africa. 259.

3. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The city the earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:2.

4. Alfassa (1967) The Mother on Auroville. Available: http://www.auroville.org/vision/maonav_selected.htm. Accessed online: July 2011.

5. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:4.

6. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:5.

7. Auroville (N.d) List of funding agencies. Available: http://www.auroville.org/organisation/supp_fund_list.htm#indian%20non. Accessed online: July 2011.

8. Joshi, K. (2008) Roger Anger: A tribute by Kareet Joshi. Available: http://www.auroville.org/vision/Roger_Anger.htm. Accessed online: July 2011.

9. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:7.

10. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:7.

11. Auroville (N.d) List of funding agencies. Available: http://www.auroville.org/organisation/supp_fund_list.htm#indian%20non. Accessed online: July 2011.

12. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:7.

13. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:7.

14. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:7.

15. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:8.

16. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:7.

17. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:7.

18. Auroville Earth Institute (N.d) About. Available: http://www.earth-auroville.com/about_us_en.php. Accessed online: July 2011.

19. Auroville (N.d.) Background. Available: http://www.auroville.org/vision/background.htm. Accessed online: July 2011.

20. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:4.

21. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:6-7.

22. Auroville (N.d) Involvement of the Government of India. Available: http://www.auroville.org/organisation/org_gov_india.htm. Accessed online: July 2011.

23. Auroville (2011) Census – Auroville population. Available: http://www.auroville.org/society/av_population.htm. Accessed online: July 2011.

24. Bhati, L. (2003) The inner dimension of globalisation and potential role of a city: Auroville – The citythe earth needs – an evolving global city, Paper presented at the 39th ISoCaRP Congress, Cairo:6.

25. Miles, M. (2007) Urban Utopias: The Built and Social Architectures of Alternative Settlements. London: Routledge.

26. CastánBroto, V. and Bulkeley, H. (2010) Case-study report: Towards Zero Carbon Development in Bangalore. Urban Transitions and Climate Change Project, University of Durham (available at www.geography.dur.ac.uk/projects/urban transitions)

27. Masdar (2011). About us. Masdar. http://www.masdar.ae/en/home/index.aspx [Accessed 19 October 2011]
Hopwood, D. (2010). Abu Dhabi's Masdar plan takes shape, Renewable Energy Focus, 11 (1), January-February 2010, 18-23.

28. Ouroussoff, N. 2010. In Arabian Desert, Sustainable City Rises. New York Times, 25 September.

29. Todd Whitman, C., Reid, C., von Klemperer, J., Radoff, J. & Roy, A. (2008) New Songdo City – The making of a new green city, Proceedings of CTBUH 8th World Conference, Dubai.

Lee, J. & Oh, J. (2008) New Songdo City and the value of flexibility: a case study of implementation and analysis of a mega-scale project. Masters Thesis. Massachusetts Institute of Technology.

Songdo IDB City Talk (2011) The smart-green city, IFEZ (Incheon Free Economic Zone). Available: http://www.songdoibdcitytalk.com/blog/?tag=green. Accessed online: Jul 2011.

Kyuri Lee, C. (2011) Interview with Gale International's Communications and Investor Relations Manager, by the author. New York, 9 August 2011.

Albers, A. (2011) Interview with Gale International's Director of Sustainable Development, by the author. New York, 9 August 2011.

30. Sfgov (2011). Treasure Island. San Fransisco Government. http://sftreasureisland.org/index.aspx?page=26 [Accessed 19 October 2011]

Kane, W. (2011). S.F approves Treasure Island plan. The San Francisco Chronicle, 8 June

31. Ornetzeder, M., & Rohracher, H. (2006) User-led innovations and participation processes: lessons from sustainable energy technologies. Energy Policy,34(2):144.

Sperling, C. (2002) Sustainable Urban District Freiburg-Vauban. Available: http://www.carstensperling.de/pdf/dubai-submission.pdf. Accessed online: Aug 2009. 2-4.

Kasioumi, E. (2010) An examination of environmentally responsible neighborhood in Europe and lessons for sustainable urban planning. Master Thesis. Massachusetts Institute of Technology. 103.

32. Sperling, C. (2002) Sustainable Urban District Freiburg-Vauban. Available: http://www.carstensperling.de/pdf/dubai-submission.pdf. Accessed online: Aug 2009. 3.

Linck, H. (2009) Quartier Vauban Freiburg - a guided tour. Stadtteilverein Vauban e.V, Freibrug. 9.

33. Based on the official UN exchange rate as per 4th March 2013 (rate of 1.309)

34. Energy Cities, & ADEME. (2008)Guidebook of Sustainable Neighbourhoods in Europe. Available:http://www.energycities.eu/IMG/pdf/ademe_sustainable_districts_en.pdf. Accessed online: Jul 2011. 13-15.

35. After 2001, the Freiburg Low-Energy Housing Construction standard of 65kWh/m2 per year became federally adopted (Scheurer& Newman, 2009:4).

36. The standard was revised in 2008 for further reductions towards nearly passive house requirements from 2011 onwards (Clinton Foundation n.d.).

37. Linck, H. (2009) Quartier Vauban Freiburg - a guided tour. Stadtteilverein Vauban e.V, Freibrug. 19-23.

38. Linck, H. (2009) Quartier Vauban Freiburg - a guided tour. Stadtteilverein Vauban e.V, Freibrug. 15-17.

Morais, G. W. (2009) Sustainable consumption, well-being and institutions: The experiences of Vauban and Växjö. Master Thesis. Freiburg University. 36-49.

39. Ornetzeder, M., & Rohracher, H. (2006) User-led innovations and participation processes: lessons from sustainable energy technologies. Energy Policy,34(2):145.

40. Morais, G. W. (2009) Sustainable consumption, well-being and institutions: The experiences of Vauban and Växjö. Master Thesis. Freiburg University. 36-49.

41. Gauzin-Müller, D. (2002) Sustainable architecture and urbanism: concepts, technologies, examples. Birkhäuser, Berlin. 74

42. City of Freiburg (2009) Statistischer Infodienst. Available: http://www.freiburg.de/servlet/PB/show/1215307/statistik_infodienst_2009-BT-Wahl.pdf. [Accessed October 2009], 13

43. Späth, P., & Rohracher, H. (2011) The "eco-cities" Freiburg and Graz - the social dynamics of pioneering urban energy and climate governance. In: H. Bulkeley, V. C. Broto, M. Hodson & S. Marvin (eds.), Cities and Low Carbon Transitions. Routledge, New York: 90.

Scheurer, J., & Newman, P. (2009) Vauban: A European Model Bridging the Green and Brown Agendas. Available: http://www.unhabitat.org/downloads/docs/GRHS2009CaseStudyChapter06Vauban.pdf. Accessed online: Aug 2011. 3.

44. City of Freiburg (2009) Statistischer Infodienst. Available: http://www.freiburg.de/servlet/PB/show/1215307/statistik_infodienst_2009-BT-Wahl.pdf. Accessed online: Oct 2009. 5–14.

45. Linck, H. (2009) Quartier Vauban Freiburg - a guided tour. Stadtteilverein Vauban e.V, Freibrug. 9.

46. Clinton Foundation (n.d) Cutting home energy consumption by 80%. Available: http://www.c40cities.org/bestpractices/buildings/freiburg_housing.jsp. Accessed online: Aug 2011.

47. Späth, P. (2005) District heating and passive houses – Interfering strategies towards sustainable energy systems. ECEEE 2005 Summer Study proceedings, Stockholm: 341-344.

48. Scheurer, J., & Newman, P. (2009) Vauban: A European Model Bridging the Green and Brown Agendas. Available: http://www.unhabitat.org/downloads/docs/GRHS2009CaseStudyChapter06Vauban.pdf. Accessed online: Aug 2011. 5.

49. www.vauban.de. English introduction to Vauban District, Freiburg. Available: http://www.vauban.de/info/abstract.html. Accessed online: Aug 2011.

Linck, H. (2009) Quartier Vauban Freiburg - a guided tour. Stadtteilverein Vauban e.V, Freibrug. 9-11.

50. Morais, G. W. (2009) Sustainable consumption, well-being and institutions: The experiences of Vauban and Växjö. Master Thesis. Freiburg University. 36-49.

51. Dzawu, M.M. (2011) Ghana Fuel-Price Hike May Boost Inflation Rate to 10%, Standard Bank Says. Bloomberg Online. Available: http://www.bloomberg.com/news/2011-01-05/ghana-fuel-price-hike-may-boost-inflation-rate-to-10-standard-bank-says.html. Accessed online: August 2011.

52. Japan International Cooperation Agency (1990) Medium to Long Term Road Improvement Plan: Main Report, Report SSFCR (3)-90-47(2). Tokyo: JICA.

53. BTS (2011) BTS Company Factsheet. Available: www.btsc.co.th. Accessed online: 12 September 2011.

54. Probe International. 2008. *Beijing's water crisis: 1949-2008 Olympics*. Ontario: Probe International.

55. Winn, R. (2008). Mariannhill Landfill Conservancy: History. http://www.landfillconservancies.com/mlc_history.htm [Accessed 15 July 2011]

56. Parkin, J. (2011). Personal communications

57. Parkin, J. (2011). Personal communications

58. Parkin, J. (2011). Personal communications

59. Strachan, L.(2007). Mariannhill Landfill Conservancy – A 'Closed Loop' Design. http://www.durban.gov.za/durban/services/cleansing/gastoelec/fill [Accessed 12 July 2011]

60. Havard Kennedy School. (2006). Mariannhill Landfill Conservancy. http://www.innovations.harvard.edu/awards.html?id=42981 [Accessed 12 July 2011]

61. Strachan, L.(2007). Mariannhill Landfill Conservancy – A 'Closed Loop' Design. http://www.durban.gov.za/durban/services/cleansing/gastoelec/fill [Accessed 12 July 2011]

62. SA Good News. (2007). Durban launches Africa's first landfill gas to electricity project. http://www.sagoodnews.co.za/environment/durban_launches_africas_first_landfill_gas_to_electricity_project.html [Accessed 12 July 2011]

63. Strachan, L.(2007). Mariannhill Landfill Conservancy – A 'Closed Loop' Design. http://www.durban.gov.za/durban/services/cleansing/gastoelec/fill [Accessed 12 July 2011]

64. Strachan, L.(2007). Mariannhill Landfill Conservancy – A 'Closed Loop' Design. http://www.durban.gov.za/durban/services/cleansing/gastoelec/fill [Accessed 12 July 2011]

65. Taylor, Y. (2009) Toxic Landfill sites! Perhaps not... http://www.earthorganization.org/articles/Library/Toxic_landfill_sites_perhaps_not/default.aspx [Accessed 12 July 2011]
Kadalie, R. (2011). Mariannhill – a dump with a massive difference. The New Age. http://thenewage.co.za/blogdetail.aspx?mid=186&blog_id=961 [Accessed 22 July 2011]

66. Taylor, Y. (2009) Toxic Landfill sites! Perhaps not... http://www.earthorganization.org/articles/Library/Toxic_landfill_sites_perhaps_not/default.aspx [Accessed 12 July 2011]

67. Moodley, S. (2007). Turning a landfill into an asset. *Delivery*. 11, 70-71

68. Wright, M. (2011) Personal communications

69. Based on the official United Nations Exchange rate as of 4th March 2013 (rate of 0.113)

70. Wright, M. (2011) Personal communications

71. Strachan, L. and Pass, J. (2010). Ch. 18: Energy from waste: An overview of Africa's first landfill gas to energy Clean Development Mechanism projects. In The Waste Revolution Handbook. Waste Revolution South Africa, Durban, 130-135
Wright, M. (2011) Personal communications

72. Wright, M. (2011) Personal communications

73. SA Good News. (2007). Durban launches Africa's first landfill gas to electricity project. http://www.sagoodnews.co.za/environment/durban_launches_africas_first_landfill_gas_to_electricity_project.html [Accessed 12 July 2011]

74. Wright, M. (2012) Personal communications

75. Havard Kennedy School. (2006). Mariannhill Landfill Conservancy. http://www.innovations.harvard.edu/awards.html?id=42981 [Accessed 12 July 2011]

76. Strachan, L.(2007). Mariannhill Landfill Conservancy – A 'Closed Loop' Design. http://www.durban.gov.za/durban/services/cleansing/gastoelec/fill [Accessed 12 July 2011]

77. Kadalie, R. (2011) Mariannhill – a dump with a massive difference. The New Age. http://thenewage.co.za/blogdetail.aspx?mid=186&blog_id=961 [Accessed 22 July 2011]

78. Winn, R. (2008). Mariannhill Landfill Conservancy: History. http://www.landfillconservancies.com/mlc_history.htm [Accessed 15 July 2011]

79. Strachan, L.(2007). Mariannhill Landfill Conservancy – A 'Closed Loop' Design. http://www.durban.gov.za/durban/services/cleansing/gastoelec/fill [Accessed 12 July 2011]

80. Moodley, S. (2007). Turning a landfill into an asset. *Delivery*. 11, 70-71

81. Parkin, J. (2011). Personal communications

82. Strachan, L. and Pass, J. (2010). Ch. 18: Energy from waste: An overview of Africa's first landfill gas to energy Clean Development Mechanism projects. In *The Waste Revolution Handbook*. Waste Revolution South Africa, Durban, 130-135

83. Wright, M. (2011) Personal communications

84. Wright, M. (2011) Personal communications

85. Garner, E. (2009). An Assessment of Waste Management Practices in South Africa: A Case Study of Mariannhill Landfill Site, eThekwini Municipality. Master's thesis. University of KwaZulu-Natal, South Africa
Parkin, J. (2011). Personal communications

86. Wright, M. (2011) Personal communications

87. Engqvist, J.H. and M. Lantz, eds. *Dharavi: Documenting Informalities*. 2008, The Royal University College of Fine Arts Art and Architecture: Stockohlm. 303.
Namakula. 2003. Garbage, Kampala's Nightmare, in The New Vision: Kampala. 24.
Nyakaana, J.B. 2000. Solid Waste management in Urban Centers; The case of Kampala City in Uganda. East African Geographical Review, 19(4).

88. Kanyonyore, M.S. 1998. Urban Conmercial Solid Waste Managment in Nakawa Division, Kampala, in Makerere Institute of Environment and Natural Resources, Makerere University: Kampala.
KCC. 2000. Waste Collection in Kampala City, Kampala City Council: Kampala.
Mugabi, S.D. 1998. *Domestic Solid Waste Management in Uganda; Attitudes, Practices and Policy Recommendations*, in *MUIENR*, Makerere University: Kampala.

89. UN-Habitat & ECA. 2008. *The State of African Cities A framework for addressing urban challenges in Africa*, United Nations Human Settlement Programme: Nairobi.

90. Engqvist, J.H. and M. Lantz, eds. 2008. Dharavi: Documenting Informalities. The Royal University College of Fine Arts Art and Architecture: Stockohlm. 303.
Buyana, K. and S. Lwasa. 2011. *From dependency to Interdependencies: The emergence of a socially rooted butcommercial waste sector in Kampala City, Uganda*. African Journal of Environmental Science and Technology, 5(2): 7.

91. Sengendo, H. 1997. Urbanization, Urban Governance and the Environment; Critical conditions for formulating and environmental strategy for Kampala, Uganda. Mawazo, 7(2).
UN-Habitat. 2009. *Planning for Sustainable Cities: Policy Directions*, in *A Global Report on Human Settlements*, United Human Settlements Programme: Nairobi.

92. Rahman, P. & Rashid, A. (2011) Some lessons learnt while working with community, government, NGOs/CBOs and some axioms. Unpublished document.
Rahman, P. (2011) Orangi Pilot Project – Institutions and Programs – a profile. Unpublished document.

93. Integrated Transport Planning Ltd and IBIS Transport Consultants Ltd. (2009). BRT-Lite Evaluation Final Report for the Lagos Metropolitan Area Transport Authority. In print
LAMATA (2008). Lagos Bus Rapid Transit Scheme (BRT). Lagos Metropolitan Area Transport Authority, Lagos
LAMATA (2009). Lagos BRT-Lite: Africa's first bus rapid transit scheme, Lagos BRT-Lite Summary Evaluation Report. Lagos Metropolitan Area Transport Authority, Nigeria
LAMATA (2007). Lagos Metropolitan Area Transport Authority (LAMATA) Brochure. In print

94. Manda, M.A.Z. (2009). *Water and Sanitation in Urban Malawi: Can they meet the Millennium Development Goals? A study of informal settlements in three cities*. Human Settlements Working Paper, International Institute for Environment and Development, London, 2

95. Manda, M.A.Z. (2009). *Water and Sanitation in Urban Malawi: Can they meet the Millennium Development Goals? A study of informal settlements in three cities*. Human Settlements Working Paper, International Institute for Environment and Development, London, 2

96. Nkhoma, S. (2011). Personal Communications

97. Morgen, P. (2007).Lessons from a Low Cost Ecological Approach to Sanitation in Malawi, Water and Sanitation Programme. Field Note, Nairobi, 3

98. Nkhoma, S. (2011). Personal Communications

99. Morgen, P. (2007).Lessons from a Low Cost Ecological Approach to Sanitation in Malawi, Water and Sanitation Programme. Field Note, Nairobi, 12

100. Nkhoma, S. (2011). Personal Communications

101. Nkhoma, S. (2011). Personal Communications

102. Manda, M.A.Z., Nkhoma, S. and Mitlin, D. (2011). Understanding pro-poor housing finance in Malawi. Human Settlements Working Paper No. 32. International Institute for Environment and Development, London, 5

103. Nkhoma, S. (2011). Personal Communications

104. Nkhoma, S. (2011). Personal Communications

105. Manda, M.A.Z. (2009). *Water and Sanitation in Urban Malawi: Can they meet the Millennium Development Goals? A study of informal settlements in three cities*. Human Settlements Working Paper, International Institute for Environment and Development, London, 6

106. CCODE (2011) Use of Ecosan Products in Malawi: Experiences from Users in Peri-Urban Areas, WIN-SA Fieldnote September 2011, Water Information Network South Africa, Pretoria, South Africa.

107. Austin, L.M., Duncker, L.C., Matsebe, G.N., Phasha, M.C. and Cloete, T.E. (2005) Ecological Sanitation- Literature Review, Water Research Commission Report No. 246/05, Gezina, 11

108. Based on the Official United Nations Exchange rate as on the 4thMarch 2013 (rate of 0.003)

109. Nkhoma, S. (2011). Personal Communications

110. Bunda College of Agriculture (2011) Evaluating Ecosan Technology, Draft Report May 2011, Bunda College of Agriculture

111. Nkhoma, S. (2011). Personal Communications

112. Nkhoma, S. (2011).Personal Communications

113. Brand, P. and Dávila, J.D. Mobility innovation at the urban margins: Medellín's *Metrocables*. City (forthcoming).

114. Brand, P. and Dávila, J.D. Mobility innovation at the urban margins: Medellín's *Metrocables*. City (forthcoming).

115. McDermott, C. (2010) Desarrollo humano y las bibliotecas públicas de Colombia. CIDER, Universidad de los Andes. Bogotá.

116. Metro de Medellín (2004) Ejemplo de intermodalidad: Sistema de transporte por cable aéreo integrado al sistema metro de Medellín.http://uprati.uprm.edu/interns/medellin/MetroCable%28PuertoRico%29.pdf. Accessed online: Aug 2011.

117. CDM Executive Board (2009) Cable Cars Metro Medellín, Colombia: Clean Development Mechanism Project Design Document Form (CDM-SSC-PDD), Version 1.3. Unpublished document.

118. Grütter, J. (2007) Cable cars for public transport. CDM form for proposed new small scale methodologies (F-CDM-SSC-NM). Unpublished document.

119. TÜV SÜD Industrie Service GmbH (2009). Validation of the CDM-Project: Cable Cars Metro Medellín, Colombia. Report No. 1241689 (2 December). Unpublished document.

120. TÜV SÜD Industrie Service GmbH (2009). Validation of the CDM-Project: Cable Cars Metro Medellín, Colombia. Report No. 1241689 (2 December). Unpublished document.

121. CDM Executive Board (2009) Cable Cars Metro Medellín, Colombia: Clean Development Mechanism Project Design Document Form (CDM-SSC-PDD), Version 1.3. Unpublished document.

122. Hylton, F. (2007) Medellín's makeover, New Left Review 44, pp. 71-89.

123. Ala-Ketola, Ulla (2010) Towards Carbon Neutral Municipalities. Envelope. Newsletter of the Finnish Environment Institute 5/2010. http://mmm.multiedition.fi/syke/envelope/Envelope_5_2010/Envelope_5_2010_HINKU.php

Finnish Environment Institute (2010) Proven by experience in five municipalities: carbon neutral municipality not a utopian idea. Press release 10 July, 2010. http://www.ymparisto.fi/default.asp?contentid=367135&lan=en&clan=en

124. Kitakyushu City (2008) Kitakyushu City Eco Tour Guide Book, 'Kougai-kokufuku' edition and 'Kankyou-Sangyou' edition
Takasugi, S. (1999) Kitakyushu Eco-Town wominiiku: 9-13, 140-170
The Ministry of Economy, Trade and Industry (2007) Eco Town Projects / Environmental Industries in Progress: 5. Available online: http://www.meti.go.jp/policy/recycle/main/3r_policy/policy/pdf/ecotown/ecotown_casebook/english.pdfAccessed August 2011.
Kitakyushu City (2011) Kitakyushu Eco-Town Project

125. Based on United Nations Exchange rate as on 4thMarch 2013 (rate of 0.011)

126. The Ministry of Economy, Trade and Industry (2007) Eco Town Projects / Environmental Industries in Progress: 5. Available online: http://www.meti.go.jp/policy/recycle/main/3r_policy/policy/pdf/ecotown/ecotown_casebook/english.pdfAccessed August 2011.

127. CoM (2003) Zero Net Emissions by 2020: A roadmap to a climate neutral city. Melbourne: City of Melbourne.

128. CoM (2003) Zero Net Emissions by 2020: A roadmap to a climate neutral city. Melbourne: City of Melbourne.

129. CoM (2003) Zero Net Emissions by 2020: A roadmap to a climate neutral city. Melbourne: City of Melbourne.

130. CoM (2003) Zero Net Emissions by 2020: A roadmap to a climate neutral city. Melbourne: City of Melbourne.

131. CoM (2003) Zero Net Emissions by 2020: A roadmap to a climate neutral city. Melbourne: City of Melbourne.

132. CoM (2008) Zero Net Emissions by 2020: Update 2008. Melbourne: City of Melbourne

133. CitySwitch (n.d.) CitySwitch Green Office. Available: http://www.cityswitch.net.au/. Accessed online: August 2011.

134. WSUD (n.d.) Environment: Saving Water. Available: http://www.melbourne.vic.gov.au/Environment/SavingWater/Documents/WSUD_part1.pdf. Accessed online: August 2011.

135. City of Melbourne (n.d.) Sustainability. Available online: http://www.melbourne.vic.gov.au. Accessed online: August 2011.

136. WSUD (n.d.) Environment: Saving Water. Available: http://www.melbourne.vic.gov.au/Environment/SavingWater/Documents/WSUD_part1.pdf. Accessed online: August 2011.

137. Eco-Innovation Lab (n.d.) Civic Report: A highly productive place. Available: http://www.ecoinnovationlab.com/ebd/68-ebd-newsletter/195-civic-report-a-highly-productive-place. Accessed online: August 2011.

138. Enterprise Melbourne (n.d.) Enterprise Melbourne: Environment. Available: http://www.melbourne.vic.gov.au/enterprisemelbourne/environment/Pages/EnvironmentVideo.aspx. Accessed online: August 2011.

139. MCFM (n.d.) Melbourne Community Farmers Markets. Available: http://mfm.com.au/content/about. Accessed online: August 2011.

140. Larsen, K., Turner, G., Ryan, C. and Lawrence, M. (2011) Victorian Food Supply Scenarios: Impacts on availability of a nutritious diet. Available: http://www.ecoinnovationlab.com/uploads/attachments/article/420/Food%20Supply%20Scenarios%20-%20Summary.pdf. Accessed online: August 2011.

141. Enterprise Melbourne (n.d.) Enterprise Melbourne: Environment. Available: http://www.melbourne.vic.gov.au/enterprisemelbourne/environment/Pages/EnvironmentVideo.aspx. Accessed online: August 2011.

142. CAP (2010). City of Portland and Multnomah County Climate Action Plan 2009 Year 1 Progress Report. Climate Action Plan. http://www.ci.portland.or.us/bps/index.cfm?a=327050&c=49989. [Accessed August 2011].

143. Hoglund, M. (2011). Portland Planning and Sustainability Commission Briefing May 24, 2011. http://www.portlandonline.com/bps/index.cfm?c=41664 [Accessed August 2011]

144. OGWC (2011). *Report to the Legislature 2011*. Oregon Global Warming Commission. http://www.keeporegoncool.org/content/oregon-global-warming-commission-report-legislature-recommends-40-key-actions [Accessed August 2011]

145. City of Portland and Portland Development Commission (2009). Portland Economic Development Strategy: A Five-Year Plan for promoting Job Creation and Economic Growth. http://pdxeconomicdevelopment.com/docs/EDS_Brochure.pdf [Accessed August 2011]

146. City of Portland and Portland Development Commission (2009). Portland Economic Development Strategy: A Five-Year Plan for promoting Job Creation and Economic Growth. http://pdxeconomicdevelopment.com/docs/EDS_Brochure.pdf [Accessed August 2011]

147. City of Portland and Portland Development Commission (2009). Portland Economic Development Strategy: A Five-Year Plan for promoting Job Creation and Economic Growth. http://pdxeconomicdevelopment.com/docs/EDS_Brochure.pdf [Accessed August 2011]

148. City of Portland and Portland Development Commission (2009). Portland Economic Development Strategy: A Five-Year Plan for promoting Job Creation and Economic Growth. http://pdxeconomicdevelopment.com/docs/EDS_Brochure.pdf [Accessed August 2011]

149. City of Portland and Portland Development Commission (2009). Portland Economic Development Strategy: A Five-Year Plan for promoting Job Creation and Economic Growth. http://pdxeconomicdevelopment.com/docs/EDS_Brochure.pdf [Accessed August 2011]

150. City of Portland and Portland Development Commission (2009). Portland Economic Development Strategy: A Five-Year Plan for promoting Job Creation and Economic Growth. http://pdxeconomicdevelopment.com/docs/EDS_Brochure.pdf [Accessed August 2011]

151. CAP (2010). City of Portland and Multnomah County Climate Action Plan 2009 Year 1 Progress Report. Climate Action Plan. http://www.ci.portland.or.us/bps/index.cfm?a=327050&c=49989. [Accessed August 2011].

152. OGWC (2011). *Report to the Legislature 2011*. Oregon Global Warming Commission. http://www.keeporegoncool.org/content/oregon-global-warming-commission-report-legislature-recommends-40-key-actions [Accessed August 2011]

153. CAP (2010). City of Portland and Multnomah County Climate Action Plan 2009 Year 1 Progress Report. Climate Action Plan. http://www.ci.portland.or.us/bps/index.cfm?a=327050&c=49989. [Accessed August 2011].

154. PPR (2009) Community Gardens Business Plan Fiscal Years 2008-09 through 2010-11. Portland Parks & Recreation. http://www.portlandonline.com/parks/index.cfm?a=246846&c=38306 [Accessed February 2012]

155. CAP (2010). City of Portland and Multnomah County Climate Action Plan 2009 Year 1 Progress Report. Climate Action Plan. http://www.ci.portland.or.us/bps/index.cfm?a=327050&c=49989. [Accessed August 2011].

156. CAP (2010). City of Portland and Multnomah County Climate Action Plan 2009 Year 1 Progress Report. Climate Action Plan. http://www.ci.portland.or.us/bps/index.cfm?a=327050&c=49989. [Accessed August 2011].

157. CAP (2010). City of Portland and Multnomah County Climate Action Plan 2009 Year 1 Progress Report. Climate Action Plan. http://www.ci.portland.or.us/bps/index.cfm?a=327050&c=49989. [Accessed August 2011].

158. Mercury News. (2007) Green goal is good for San Jose: Silicon Valley should be leader as nation seeks best technology for sustainable development. San Jose Mercury News, California. 7 October 2007.

159. CoSJ (City of San Jose) (2010) Green Vision 2010 Annual Report. Available: http://www.sanjoseca.gov/clerk/Agenda/20110322/20110322_0701att.pdf Accessed online: 4 August 2011.

160. CoSJ (City of San Jose) (2010a) Green Vision 2010 Annual Report. Available: http://www.sanjoseca.gov/clerk/Agenda/20110322/20110322_0701att.pdf Accessed online: 4 August 2011.

161. CoSJ (City of San Jose) (2010a) Green Vision 2010 Annual Report. Available: http://www.sanjoseca.gov/clerk/Agenda/20110322/20110322_0701att.pdf Accessed online: 4 August 2011.

162. Greenberg, A. (2010) San Jose residents produce more U.S. patents than any other city. Forbes.com. 24 May 2010. Available: http://www.forbes.com/2010/05/24/patents-funding-jobs-technology-innovative-cities.html. Accessed online: 4 August 2011.

163. CoSJ (City of San Jose) (2010a) Green Vision 2010 Annual Report. Available: http://www.sanjoseca.gov/clerk/Agenda/20110322/20110322_0701att.pdf Accessed online: 4 August 2011.

164. Nauman, M. (2007) San Jose mayor unveils green vision: key question – how are we going to pay for it? San Jose Mercury News, California. 5 October 2010.

165. CoSJ (City of San Jose) (2010b) San Jose's Green Vision. Official website of the City of San Jose. Available: http://greenvision.sanjoseca.gov/. Accessed online: 4 August 2011.

166. CoSJ (City of San Jose) (2010a) Green Vision 2010 Annual Report. Available: http://www.sanjoseca.gov/clerk/Agenda/20110322/20110322_0701att.pdf Accessed online: 4 August 2011.

167. CoSJ (City of San Jose) (2010a) Green Vision 2010 Annual Report. Available: http://www.sanjoseca.gov/clerk/Agenda/20110322/20110322_0701att.pdf Accessed online: 4 August 2011.

168. CoSJ (City of San Jose) (2010b) San Jose's Green Vision. Official website of the City of San Jose. Available: http://greenvision.sanjoseca.gov/. Accessed online: 4 August 2011.

169. CoSJ (City of San Jose) (2010a) Green Vision 2010 Annual Report. Available: http://www.sanjoseca.gov/clerk/Agenda/20110322/20110322_0701att.pdf Accessed online: 4 August 2011.

170. Molina, J. (2007) S.J. pursues Willow Glen spur trail. San Jose Mercury News, California. 7 November 2007.

171. CoSJ (City of San Jose) (2010a) Green Vision 2010 Annual Report. Available: http://www.sanjoseca.gov/clerk/Agenda/20110322/20110322_0701att.pdf Accessed online: 4 August 2011.

172. Krinn, K. (2011) Lemonade in the new normal. Journal of Environmental Health. Vol 73(7). March 2011.

173. CoSJ (City of San Jose) (2010a) Green Vision 2010 Annual Report. Available: http://www.sanjoseca.gov/clerk/Agenda/20110322/20110322_0701att.pdf Accessed online: 4 August 2011.

174. Mercury News (2007) Finding gold in green buildings in San Jose: Some developers will need city's push for building standards. San Jose Mercury News, California. 23 November 2007.

175. Woolfolk, J. (2008) S.J. lures another solar company: $700,000 package will help firm move from Menlo Park.San Jose Mercury News, California. 12 March 2008.

176. Nauman, M. (2007) San Jose mayor unveils green vision: key question – how are we going to pay for it? San Jose Mercury News, California. 5 October 2010.

177. Tortajada, C. (2006). Singapore: an exemplary case for urban water management. Paper prepared for the 2006 Human Development Report. http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1270074782769/Eco2_Cities_Book.pdf [Accessed October 2011]

178. MEWR (2009). *A Lively and Liveable Singapore: Strategies for Sustainable Growth*. Ministry of the Environment and Water Resources and Ministry of National Development. http://app.mewr.gov.sg/data/ImgCont/1292/sustainblebluepprint_forweb.pdf. [Accessed October 2011]

179. SSNC (2010). Singapore's Second National Communication under the United Nations Framework Convention on Climate Change November 2010. National Environment Agency. http://app.mewr.gov.sg/data/imgCont/1439/singapore_snc2010.pdf [Accessed October 2011]

180. MEWR (2009). *A Lively and Liveable Singapore: Strategies for Sustainable Growth*. Ministry of the Environment and Water Resources and Ministry of National Development. http://app.mewr.gov.sg/data/ImgCont/1292/sustainblebluepprint_forweb.pdf. [Accessed October 2011]

181. MEWR (2009). *A Lively and Liveable Singapore: Strategies for Sustainable Growth*. Ministry of the Environment and Water Resources and Ministry of National Development. http://app.mewr.gov.sg/data/ImgCont/1292/sustainblebluepprint_forweb.pdf. [Accessed October 2011]

182. MEWR (2009). *A Lively and Liveable Singapore: Strategies for Sustainable Growth*. Ministry of the Environment and Water Resources and Ministry of National Development. http://app.mewr.gov.sg/data/ImgCont/1292/sustainblebluepprint_forweb.pdf. [Accessed October 2011]

183. MEWR (2009). *A Lively and Liveable Singapore: Strategies for Sustainable Growth*. Ministry of the Environment and Water Resources and Ministry of National Development. http://app.mewr.gov.sg/data/ImgCont/1292/sustainblebluepprint_forweb.pdf. [Accessed October 2011]

184. MEWR (2009). *A Lively and Liveable Singapore: Strategies for Sustainable Growth*. Ministry of the Environment and Water Resources and Ministry of National Development. http://app.mewr.gov.sg/data/ImgCont/1292/sustainbleblueprint_forweb.pdf. [Accessed October 2011]

185. Based on United Nations Exvhange rate as on 4th March 2013 (rate of 0.808)

186. NCCS (2010). Transcript of Minister for the Environment and Water Resources Dr Yaacob Ibrahim's reply to Parliamentary question on the Singapore Sustainable Blueprint on 11 January 2010. http://app.nccs.gov.sg/news_details.aspx?nid=98. [Accessed October 2011]

187. EDB (2009). S$1 billion environmental blueprint to make Singapore a clean technology and urban solutions hub. Economic Development Board Singapore. http://www.edb.gov.sg/edb/sg/en_uk/index/news/articles/s_1_billion_environmental.html [Accessed October 2011]

188. NCCS (2010). Transcript of Minister for the Environment and Water Resources Dr Yaacob Ibrahim's reply to Parliamentary question on the Singapore Sustainable Blueprint on 11 January 2010. http://app.nccs.gov.sg/news_details.aspx?nid=98. [Accessed October 2011]

189. SSNC (2010). Singapore's Second National Communication under the United Nations Framework Convention on Climate Change November 2010. National Environment Agency. http://app.mewr.gov.sg/data/imgCont/1439/singapore_snc2010.pdf [Accessed October 2011]

190. Tortajada, C. (2006). Singapore: an exemplary case for urban water management. Paper prepared for the 2006 Human Development Report. http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1270074782769/Eco2_Cities_Book.pdf [Accessed October 2011]

191. PUB (2011). *Go with more ticks to save water*. Public Utility Board Singapore. http://www.pub.gov.sg/mpublications/Pages/PressReleases.aspx?ItemId=323 [Accessed October 2011]

192. SSNC (2010). Singapore's Second National Communication under the United Nations Framework Convention on Climate Change November 2010. National Environment Agency. http://app.mewr.gov.sg/data/imgCont/1439/singapore_snc2010.pdf [Accessed October 2011]

193. PUB (2011). *Go with more ticks to save water*. Public Utility Board Singapore. http://www.pub.gov.sg/mpublications/Pages/PressReleases.aspx?ItemId=323 [Accessed October 2011]

194. SSNC (2010). Singapore's Second National Communication under the United Nations Framework Convention on Climate Change November 2010. National Environment Agency. http://app.mewr.gov.sg/data/imgCont/1439/singapore_snc2010.pdf [Accessed October 2011]

195. SSNC (2010). Singapore's Second National Communication under the United Nations Framework Convention on Climate Change November 2010. National Environment Agency. http://app.mewr.gov.sg/data/imgCont/1439/singapore_snc2010.pdf [Accessed October 2011]

196. SSNC (2010). Singapore's Second National Communication under the United Nations Framework Convention on Climate Change November 2010. National Environment Agency. http://app.mewr.gov.sg/data/imgCont/1439/singapore_snc2010.pdf [Accessed October 2011]

197. PUB (2011). *Go with more ticks to save water*. Public Utility Board Singapore. http://www.pub.gov.sg/mpublications/Pages/PressReleases.aspx?ItemId=323 [Accessed October 2011]

198. PUB (2011). *Go with more ticks to save water*. Public Utility Board Singapore. http://www.pub.gov.sg/mpublications/Pages/PressReleases.aspx?ItemId=323 [Accessed October 2011]

199. MEWR (2011). Water Resource Management. Ministry of the Environment and Water Resources. http://app.mewr.gov.sg/web/Contents/Contents.aspx?ContId=682 [Accessed October 2011]

200. PUB (2011). *Go with more ticks to save water*. Public Utility Board Singapore. http://www.pub.gov.sg/mpublications/Pages/PressReleases.aspx?ItemId=323 [Accessed October 2011]

201. MEWR (2011). Water Resource Management. Ministry of the Environment and Water Resources. http://app.mewr.gov.sg/web/Contents/Contents.aspx?ContId=682 [Accessed October 2011]

202. Chew, V. (2009). Singapore-Malaysia Water Agreements. www.infopedia.nl.sg [Accessed October 2011]

203. SSNC (2010). Singapore's Second National Communication under the United Nations Framework Convention on Climate Change November 2010. National Environment Agency. http://app.mewr.gov.sg/data/imgCont/1439/singapore_snc2010.pdf [Accessed October 2011]

204. TransitionNetwork.org (2011)Web-site: Transition Network. Available: https://www.transitionnetwork.org. Accessed online: July 2011.

205. Brangwyn, B. (2011) Interview with Ben Brangwyn, co-founder of the Transition Network, Totnes, August 2011.

206. Hopkins, R. (2009) The Transition Handbook: From oil dependency to local resilience, Green Books Ltd, Dartington. 172.

207. TTT (2011) Web-site: Transition Town Totnes. Available: http://www.transitiontowntotnes.org/projects. Accessed online: July 2011

208. TTT (2011) Web-site: Transition Town Totnes. Available: http://www.transitiontowntotnes.org/projects. Accessed online: July 2011

209. Hopkins, R. (2009) The Transition Handbook: From oil dependency to local resilience, Green Books Ltd, Dartington.

210. Brangwyn, B. (2011) Interview with Ben Brangwyn, co-founder of the Transition Network, Totnes, August 2011.

211. Brangwyn, B. (2011) Interview with Ben Brangwyn, co-founder of the Transition Network, Totnes, August 2011.

212. Brangwyn, B. (2011) Interview with Ben Brangwyn, co-founder of the Transition Network, Totnes, August 2011.

213. TTT (2011) Web-site: Transition Town Totnes. Available: http://www.transitiontowntotnes.org/projects. Accessed online: July 2011

214. Brangwyn, B. (2011) Interview with Ben Brangwyn, co-founder of the Transition Network, Totnes, August 2011.

215. Brangwyn, B. (2011) Interview with Ben Brangwyn, co-founder of the Transition Network, Totnes, August 2011.

216. Beatley, T. (2007) Envisioning Solar Cities: Urban Futures Powered By Sustainable Energy. Journal of Urban Technology, 14(2): 38-39.

Gustavsson, E., Elander, I., & Lundmark, M. (2006) Multilevel governance, networking cities and climate change: experiences from two swedish cities. Paper presented at the Sixth European Urban & Regional Studies Conference Roskilde, Denmark: 14.

217. City of Växjö (2010) Fossil Fuel Free Växjö. Available: http://vaxjo.se/upload/www.vaxjo.se/Kommunledningsf%C3%B6rvaltningen/Planeringskontoret/Fossil%20Fuel%20Free%20V%C3%A4xj%C3%B6%20-%20the%20story_2010.pdf. Accessed online: Jul 2011. 5.

218. City of Växjö. (2006) Environmental Programme. Växjö: 6

219. City of Växjö (2010) Fossil Fuel Free Växjö. Available: http://vaxjo.se/upload/www.vaxjo.se/Kommunledningsf%C3%B6rvaltningen/Planeringskontoret/Fossil%20Fuel%20Free%20V%C3%A4xj%C3%B6%20-%20the%20story_2010.pdf. Accessed online: Jul 2011. 5.

220. Mårtensson, K., & Westerberg, K. (2007) How to transform local energy systems towards bioenergy? Three strategy models for transformation. Energy Policy, 35(12): 6099.

221. Växjö Energi AB (n.d.) Växjö Energi - a challenge. Available: http://www.veab.se/In-English.aspx. Accessed online: Oct 2009.

222. City of Växjö (n.d.) Fossil Fuel Free Växjö [Brochure]. Available: http://vaxjo.se/upload/www.vaxjo.se/Kommunledningsf%C3%B6rvaltningen/Planeringskontoret/08%20Fbf%20V%C3%A4xj%C3%B6.pdf. Accessed online: Jul 2011. 9.

223. City of Växjö (2010) Fossil Fuel Free Växjö. Available: http://vaxjo.se/upload/www.vaxjo.se/Kommunledningsf%C3%B6rvaltningen/Planeringskontoret/Fossil%20Fuel%20Free%20V%C3%A4xj%C3%B6%20-%20the%20story_2010.pdf. Accessed online: Jul 2011. 4-7.

224. City of Växjö (n.d.) Fossil Fuel Free Växjö [Brochure]. Available: http://vaxjo.se/upload/www.vaxjo.se/Kommunledningsf%C3%B6rvaltningen/Planeringskontoret/08%20Fbf%20V%C3%A4xj%C3%B6.pdf. Accessed online: Jul 2011. 9.

225. Morais, G. W. (2009) Sustainable consumption, well-being and institutions: The experiences of Vauban and Växjö. Master Thesis. Freiburg University. 60.

226. Clinton Foundation (n.d.) Växjö is halfway to becoming fossil fuel free. Available: http://www.c40cities.org/bestpractices/renewables/vaxjo_fossilfuel.jsp. Accessed online: Sep 2009.

227. Morais, G. W. (2009) Sustainable consumption, well-being and institutions: The experiences of Vauban and Växjö. Master Thesis. Freiburg University. 60.

228. City of Växjö (2010) Fossil Fuel Free Växjö. Available: http://vaxjo.se/upload/www.vaxjo.se/Kommunledningsf%C3%B6rvaltningen/Planeringskontoret/Fossil%20Fuel%20Free%20V%C3%A4xj%C3%B6%20-%20the%20story_2010.pdf. Accessed online: Jul 2011. 4.

229. City of Växjö (2010) Fossil Fuel Free Växjö. Available: http://vaxjo.se/upload/www.vaxjo.se/Kommunledningsf%C3%B6rvaltningen/Planeringskontoret/Fossil%20Fuel%20Free%20V%C3%A4xj%C3%B6%20-%20the%20story_2010.pdf. Accessed online: Jul 2011. 9-13.

Morais, G. W. (2009) Sustainable consumption, well-being and institutions: The experiences of Vauban and Växjö. Master Thesis. Freiburg University. 62.

230. City of Växjö (2010) Fossil Fuel Free Växjö. Available: http://vaxjo.se/upload/www.vaxjo.se/Kommunledningsf%C3%B6rvaltningen/Planeringskontoret/Fossil%20Fuel%20Free%20V%C3%A4xj%C3%B6%20-%20the%20story_2010.pdf. Accessed online: Jul 2011. 9.

231. City of Växjö (2010) Fossil Fuel Free Växjö. Available: http://vaxjo.se/upload/www.vaxjo.se/Kommunledningsf%C3%B6rvaltningen/Planeringskontoret/Fossil%20Fuel%20Free%20V%C3%A4xj%C3%B6%20-%20the%20story_2010.pdf. Accessed online: Jul 2011. 9-10.

232. City of Växjö (2010) Fossil Fuel Free Växjö. Available: http://vaxjo.se/upload/www.vaxjo.se/Kommunledningsf%C3%B6rvaltningen/Planeringskontoret/Fossil%20Fuel%20Free%20V%C3%A4xj%C3%B6%20-%20the%20story_2010.pdf. Accessed online: Jul 2011. 10.

233. Beatley, T. (2007) Envisioning Solar Cities: Urban Futures Powered By Sustainable Energy. Journal of Urban Technology, 14(2): 39.

Granberg, M., & Elander, I. (2007) Local Governance and Climate Change: Reflections on the Swedish Experience. Local Environment, 12(5): 542.

Gustavsson, E., Elander, I., & Lundmark, M. (2006) Multilevel governance, networking cities and climate change: experiences from two swedish cities. Paper presented at the Sixth European Urban & Regional Studies Conference Roskilde, Denmark: 14-15.

234. Based on the official United Nations Exchange Rate, as at 4th March 2013 (rate of 0.198).

235. Pengue W. (2002) Aúnnosquedanlasmanos y la tierra (*Still we have our hands and land*). Le Monde Diplomatique. Buenos Aires.

236. Pengue W. (2002) Aúnnosquedanlasmanos y la tierra (*Still we have our hands and land*). Le Monde Diplomatique. Buenos Aires.

237. Spiaggi, E. (2005) Urban agriculture and local sustainable agriculture in Rosario, Argentina Integration of social, economical, technical and environmental variables in Mougeot, L. Agropolis: The social, political and environmental dimensions of urban agriculture. Earthscan.

238. GolsbergC. and Dumrauf, S. 2010. Agricultura familiar : ferias de la agricultura familiar en la Argentina. 1a ed. - Buenos Aires : Ediciones INTA, ISBN 978-987-1623-60-0.

239. Rees, W. and Wackernagel, M. (1996) Urban ecological footprints: why cities cannot be sustainable - and why they are a key to sustainability. Environ. Impact Assessment Rev. 16, pp. 223–248.

240. Bolund P and Humhammar, S. (1999) Ecosystem services in urban areas. Ecological Economics Volume 29, Issue 2, May 1999, Pages 293-301.

241. Pengue, W. (2009) La economía ecológica y su contribución a la sostenibilidad urbana (*Ecological Economics and its contribution for urban sustainability*) in Pengue, W.A. Fundamentals of Ecological Economics. Kaicron. Buenos Aires 978-987-23841-8-0.

242. Cousins, T. &Mahote, F. (2003) Social Research for Kuyasa Pilot CDM Project Activity. Prepared for SouthSouthNorth, Cape Town, South Africa.

243. Cousins, T. &Mahote, F. (2003) Social Research for Kuyasa Pilot CDM Project Activity. Prepared for SouthSouthNorth, Cape Town, South Africa.

244. Cousins, T. &Mahote, F. (2003) Social Research for Kuyasa Pilot CDM Project Activity. Prepared for SouthSouthNorth, Cape Town, South Africa.

245. Goldman, M. (2010) Kuyasa CDM Project: Renewable Energy Efficient Technology for the Poor. GIM Case Study No. B070. New York: United Nations Development Programme.

246. City of Cape Town. (2007) Kuyasa Energy Efficiency Project. Available: http://www.capetown.gov.za/en/EnvironmentalResourceManagement/projects/ClimateChange/Pages/KuyasaEnergyEfficiencyProject.aspx. Accessed online: July 20 2011.

247. City of Cape Town. (2007) Kuyasa Energy Efficiency Project. Available: http://www.capetown.gov.za/en/EnvironmentalResourceManagement/projects/ClimateChange/Pages/KuyasaEnergyEfficiencyProject.aspx. Accessed online: July 20 2011.

248. Goldman, M. (2010) Kuyasa CDM Project: Renewable Energy Efficient Technology for the Poor. GIM Case Study No. B070. New York: United Nations Development Programme.

249. City of Cape Town. (2007) Kuyasa Energy Efficiency Project. Available: http://www.capetown.gov.za/en/EnvironmentalResourceManagement/projects/ClimateChange/Pages/KuyasaEnergyEfficiencyProject.aspx. Accessed online: July 20 2011.

SSN (SouthSouthNorth). (2011) Official website of SouthSouthNorth. Available: www.southsouthnorth.org. Accessed online: 22 July 2011.

250. Goldman, M. (2010) Kuyasa CDM Project: Renewable Energy Efficient Technology for the Poor. GIM Case Study No. B070. New York: United Nations Development Programme.

251. Goldman, M. (2010) Kuyasa CDM Project: Renewable Energy Efficient Technology for the Poor. GIM Case Study No. B070. New York: United Nations Development Programme.

Kuyasa CDM. (2011) Official website of Kuyasa CDM Project. Available: http://www.kuyasacdm.co.za. Accessed online: 20 July 2011.

252. Based on United Nations Exchange rate as on 4th March 2013 (rate of 0.113)

253. Ndamane, Z. (2011) Informal interview with author at KuyasaCDM site office. 28 July 2011. Khayelitsha, Cape Town, South Africa.

254. City of Cape Town. (2007) Kuyasa Energy Efficiency Project. Available: http://www.capetown.gov.za/en/EnvironmentalResourceManagement/projects/ClimateChange/Pages/KuyasaEnergyEfficiencyProject.aspx. Accessed online: July 20 2011.

Goldman, M. (2010) Kuyasa CDM Project: Renewable Energy Efficient Technology for the Poor. GIM Case Study No. B070. New York: United Nations Development Programme.

255. Kuyasa CDM. (2011) Official website of Kuyasa CDM Project. Available: http://www.kuyasacdm.co.za. Accessed online: 20 July 2011.

256. Winkler, H. (2007) Energy efficiency and the CDM in South Africa: constraints and opportunities. Journal of Energy in Southern Africa. 1(18):29-38.

City of Cape Town. (2007) Kuyasa Energy Efficiency Project. Available: http://www.capetown.gov.za/en/EnvironmentalResourceManagement/projects/ClimateChange/Pages/KuyasaEnergyEfficiencyProject.aspx. Accessed online: July 20 2011.

257. Kretzmann, S. (2009) Kuyasa Carbon Credits Cut Electricity Costs. West Cape News. Available: http://westcapenews.com/?p=844. Accessed online: 20 July 2011.

Kuyasa CDM. (2011) Official website of Kuyasa CDM Project. Available: http://www.kuyasacdm.co.za. Accessed online: 20 July 2011.

258. Wlokas, H. &Wesselink, R. (2009) CDM Monitoring Report: Kuyasa low-cost urban housing energy upgrade project. 1st September 2005 to 28 February 2009. Cape Town, South Africa.

259. Kuyasa CDM. (2011) Official website of Kuyasa CDM Project. Available: http://www.kuyasacdm.co.za. Accessed online: 20 July 2011.

260. Kretzmann, S. (2009) Kuyasa Carbon Credits Cut Electricity Costs. West Cape News. Available: http://westcapenews.com/?p=844. Accessed online: 20 July 2011.

Goldman, M. (2010) Kuyasa CDM Project: Renewable Energy Efficient Technology for the Poor. GIM Case Study No. B070. New York: United Nations Development Programme.

Kuyasa CDM. (2011) Official website of Kuyasa CDM Project. Available: http://www.kuyasacdm.co.za. Accessed online: 20 July 2011.

261. Ndamane, Z. (2011) Informal interview with author at KuyasaCDM site office. 28 July 2011. Khayelitsha, Cape Town, South Africa.

262. Kuyasa CDM. (2011) Official website of Kuyasa CDM Project. Available: http://www.kuyasacdm.co.za. Accessed online: 20 July 2011.

263. Carbon Programmes. (2010) The National Sustainable Settlements Facility. Available: http://www.carbonprogrammes.co.za/projects-NSHF.php. Accessed online: 25 July 2011.

Ndamane, Z. (2011) Informal interview with author at KuyasaCDM site office. 28 July 2011. Khayelitsha, Cape Town, South Africa.

264. Ndamane, Z. (2011) Informal interview with author at KuyasaCDM site office. 28 July 2011. Khayelitsha, Cape Town, South Africa.

265. Carbon Programmes. (2010) The National Sustainable Settlements Facility. Available: http://www.carbonprogrammes.co.za/projects-NSHF.php. Accessed online: 25 July 2011.

266. Winkler, H. (2007) Energy efficiency and the CDM in South Africa: constraints and opportunities. Journal of Energy in Southern Africa. 1(18):29-38.

267. Carbon Programmes. (2010) The National Sustainable Settlements Facility. Available: http://www.carbonprogrammes.co.za/projects-NSHF.php. Accessed online: 25 July 2011.

268. Centre for Science and Environment [CSE] (2001) Managing water in Chennai. New Delhi, India. 3.

269. Centre for Science and Environment [CSE] (2010) Legislation on Rainwater Harvesting, Implementation of the Bye-Laws in different States and Cities. Available:http://www.cseindia.org/node/1111. Accessed online: August 2011.

270. Centre for Science and Environment [CSE] (2001) Managing water in Chennai. New Delhi, India. 9.

271. Arabindoo, P. (2011) Mobilising for water: hydro-politics of rainwater harvesting in Chennai. International Journal of Urban Sustainable Development, 3(1): 120.

272. Arabindoo, P. (2011) Mobilising for water: hydro-politics of rainwater harvesting in Chennai. International Journal of Urban Sustainable Development, 3(1): 121.

273. Arabindoo, P. (2011) Mobilising for water: hydro-politics of rainwater harvesting in Chennai. International Journal of Urban Sustainable Development, 3(1): 117.

274. Anastácio, A. and Schmeiske, O. (2001). Identificação e Avaliação de Canais de LogísticaReversa. InstitutodePesquisa e PlanejamentoUrbano de Curitiba. http://www.abepro.org.br/biblioteca/ENEGEP2001_TR11_0014.pdf [Accessed August 2011]

Braga, M. and Bonetto, E. (1993). Solid waste management in Curitiba, Brazil – alternative solutions. Journal of Resource Management and Technology, 21(1), 11-14

IPPUC (2011). Curitiba em Dados. Instituto de Pesquisa e PlanejamentoUrbano de Curitiba. http://www.ippuc.org.br [Accessed August 2011]

Oliveira, M. (2001). A Trajetória do discursoAmbientalem Curitiba. http://www.scielo.br/pdf/rsocp/n16/a06n16.pdf [Accessed August 2011]

Prefeitura Municipal de Curitiba (1999). PesquisaSobreosDepósitos e ColetoresInformais de MateriaisRecicláveis do Município de Curitiba. In print

Prefeitura Municipal de Curitiba / Secretaria Municipal do MeioAmbiente. (2000). Gerenciamento dos ResíduosSólidosUrbanos no Município de Curitiba. In print

Rohn, T. (2007). Improvements to Curitiba´s waste disposal system: A comparative study between Curitiba and Germany solution. http://www.design.ufpr.br/issd/papers/ISSD1101.pdf [Accessed August 2011]

275. *This case study is summarised from Section 2 of the report "Innovation in Social Transition Stage in Housing for the Low Income and Solid Waste Collection Service in Ho Chi Minh City, Vietnam," as part of the Asian City Innovation Systems Initiative Project, in which the case study author is the principal investigator. The Vietnam case study was conducted by a team led by Dr. Nguyen Minh Hoa and Dr. Pham Gia Tran.*

276. Berglund, B., Ersson, C., Ekland, M. and Martin, M. (2011). Challenges for developing a system for biogas as vehicle fuel – lessons from Linkoping, Sweden. In: *World Renewable Energy Congress 2011 – Sweden Bioenergy Technology (BE), 8-11 May 2011, Linköping*

277. Martin, M. (2009). *The "Biogasification" of Linköping: A Large Technical Systems Perspective*. Environmental Technology and Management, Linköping Universitet. http://www.iei.liu.se/envtech/forskning/forskningsprojekt/synergibiodrivmedel/1.187129/BiogasificationofLinkopingLTSFINAL.pdf [Accessed 30 July 2011]

278. Martin, M. (2009). *The "Biogasification" of Linköping: A Large Technical Systems Perspective*. Environmental Technology and Management, Linköping Universitet. http://www.iei.liu.se/envtech/forskning/forskningsprojekt/synergibiodrivmedel/1.187129/BiogasificationofLinkopingLTSFINAL.pdf [Accessed 30 July 2011]

279. Ericson, J. (2005). *Svensk Biogas AB in Linköping (Sweden)*. Osmose. http://www.osmose-os.org/documents/5/CaseStudyBiogasLinkoping(SE)2.pdf. [Accessed 3 August 2011]

280. Martin, M. (2009). *The "Biogasification" of Linköping: A Large Technical Systems Perspective*. Environmental Technology and Management, Linköping Universitet. http://www.iei.liu.se/envtech/forskning/forskningsprojekt/synergibiodrivmedel/1.187129/BiogasificationofLinkopingLTSFINAL.pdf [Accessed 30 July 2011]

281. Berglund, B., Ersson, C., Ekland, M. and Martin, M. (2011). Challenges for developing a system for biogas as vehicle fuel – lessons from Linkoping, Sweden. In: *World Renewable Energy Congress 2011 – Sweden Bioenergy Technology (BE), 8-11 May 2011, Linköping*

282. Ericson, J. and Grahn, M. (2010). *Biogas as fuel for transport in Linköping (Sweden)*.Eltis. http://www.eltis.org/index.php?id=13&study_id=2733 [Accessed 30 July 2011]

283. Barbero, S. (2011). Systemic Design in Energy Sector: Theory and Case Studies. ActaTechnicaCorviniensis. Bulletin of Engineering. Tome IV. ISSN 2067-3809

284. Barbero, S. (2011). Systemic Design in Energy Sector: Theory and Case Studies. ActaTechnicaCorviniensis. Bulletin of Engineering. Tome IV. ISSN 2067-3809

285. Berglund, B., Ersson, C., Ekland, M. and Martin, M. (2011). Challenges for developing a system for biogas as vehicle fuel – lessons from Linkoping, Sweden. In: *World Renewable Energy Congress 2011 – Sweden Bioenergy Technology (BE), 8-11 May 2011, Linköping*

286. Barbero, S. (2011). Systemic Design in Energy Sector: Theory and Case Studies. ActaTechnicaCorviniensis. Bulletin of Engineering. Tome IV. ISSN 2067-3809

287. Barbero, S. (2011). Systemic Design in Energy Sector: Theory and Case Studies. ActaTechnicaCorviniensis. Bulletin of Engineering. Tome IV. ISSN 2067-3809

288. Berglund, B., Ersson, C., Ekland, M. and Martin, M. (2011). Challenges for developing a system for biogas as vehicle fuel – lessons from Linkoping, Sweden. In: *World Renewable Energy Congress 2011 – Sweden Bioenergy Technology (BE), 8-11 May 2011, Linköping*

289. Martin, M. (2009). *The "Biogasification" of Linköping: A Large Technical Systems Perspective*. Environmental Technology and Management, Linköping Universitet. http://www.iei.liu.se/envtech/forskning/forskningsprojekt/synergibiodrivmedel/1.187129/BiogasificationofLinkopingLTSFINAL.pdf [Accessed 30 July 2011]

290. Ericson, J. (2005). *Svensk Biogas AB in Linköping (Sweden)*. Osmose. http://www.osmose-os.org/documents/5/CaseStudyBiogasLinkoping(SE)2.pdf. [Accessed 3 August 2011]

291. Ericson, J. (2005). *Svensk Biogas AB in Linköping (Sweden)*. Osmose. http://www.osmose-os.org/documents/5/CaseStudyBiogasLinkoping(SE)2.pdf. [Accessed 3 August 2011]

292. IEA (2005). *100% Biogas for urban transport in Linkoping, Sweden*. International Energy Agency. http://www.iea-biogas.net/_download/linkoping_final.pdf. [Accessed 28 July 2011]

293. Berglund, B., Ersson, C., Ekland, M. and Martin, M. (2011). Challenges for developing a system for biogas as vehicle fuel – lessons from Linkoping, Sweden. In: *World Renewable Energy Congress 2011 – Sweden Bioenergy Technology (BE), 8-11 May 2011, Linköping*

294. Berglund, B., Ersson, C., Ekland, M. and Martin, M. (2011). Challenges for developing a system for biogas as vehicle fuel – lessons from Linkoping, Sweden. In: *World Renewable Energy Congress 2011 – Sweden Bioenergy Technology (BE), 8-11 May 2011, Linköping*

295. IEA (2005). *100% Biogas for urban transport in Linkoping, Sweden*. International Energy Agency. http://www.iea-biogas.net/_download/linkoping_final.pdf. [Accessed 28 July 2011]

296. Barbero, S. (2011). Systemic Design in Energy Sector: Theory and Case Studies. ActaTechnicaCorviniensis. Bulletin of Engineering. Tome IV. ISSN 2067-3809

297. Svensk Biogas (2011). *Biogas – for a sustainable society*. http://www.svenskbiogas.se/sb/Biogas-Sustainable-society_eng_webb.pdf [Accessed 30 July 2011]

298. IEA (2005). *100% Biogas for urban transport in Linkoping, Sweden*. International Energy Agency. http://www.iea-biogas.net/_download/linkoping_final.pdf. [Accessed 28 July 2011]

299. IEA (2005). *100% Biogas for urban transport in Linkoping, Sweden*. International Energy Agency. http://www.iea-biogas.net/_download/linkoping_final.pdf. [Accessed 28 July 2011]

300. Ericson, J. (2005). *Svensk Biogas AB in Linköping (Sweden)*. Osmose. http://www.osmose-os.org/documents/5/CaseStudyBiogasLinkoping(SE)2.pdf. [Accessed 3 August 2011]

301. Svensk Biogas (2011). *Biogas – for a sustainable society*. http://www.svenskbiogas.se/sb/Biogas-Sustainable-society_eng_webb.pdf [Accessed 30 July 2011]

302. Svensk Biogas (2011). *Biogas – for a sustainable society*. http://www.svenskbiogas.se/sb/Biogas-Sustainable-society_eng_webb.pdf [Accessed 30 July 2011]

303. Ericson, J. (2005). *Svensk Biogas AB in Linköping (Sweden)*. Osmose. http://www.osmose-os.org/documents/5/CaseStudyBiogasLinkoping(SE)2.pdf. [Accessed 3 August 2011]

304. Ericson, J. (2005). *Svensk Biogas AB in Linköping (Sweden)*. Osmose. http://www.osmose-os.org/documents/5/CaseStudyBiogasLinkoping(SE)2.pdf. [Accessed 3 August 2011]

305. Berglund, B., Ersson, C., Ekland, M. and Martin, M. (2011). Challenges for developing a system for biogas as vehicle fuel – lessons from Linkoping, Sweden. In: *World Renewable Energy Congress 2011 – Sweden Bioenergy Technology (BE), 8-11 May 2011, Linköping*

306. Barbero, S. (2011). Systemic Design in Energy Sector: Theory and Case Studies. ActaTechnicaCorviniensis. Bulletin of Engineering. Tome IV. ISSN 2067-3809

307. Barbero, S. (2011). Systemic Design in Energy Sector: Theory and Case Studies. ActaTechnicaCorviniensis. Bulletin of Engineering. Tome IV. ISSN 2067-3809

308. Berglund, B., Ersson, C., Ekland, M. and Martin, M. (2011). Challenges for developing a system for biogas as vehicle fuel – lessons from Linkoping, Sweden. In: *World Renewable Energy Congress 2011 – Sweden Bioenergy Technology (BE), 8-11 May 2011, Linköping*

309. Berglund, B., Ersson, C., Ekland, M. and Martin, M. (2011). Challenges for developing a system for biogas as vehicle fuel – lessons from Linkoping, Sweden. In: *World Renewable Energy Congress 2011 – Sweden Bioenergy Technology (BE), 8-11 May 2011, Linköping*

310. Barbero, S. (2011). Systemic Design in Energy Sector: Theory and Case Studies. ActaTechnicaCorviniensis. Bulletin of Engineering. Tome IV. ISSN 2067-3809

311. Martin, M. (2009). *The "Biogasification" of Linköping: A Large Technical Systems Perspective*. Environmental Technology and Management, Linköping Universitet. http://www.iei.liu.se/envtech/forskning/forskningsprojekt/synergibiodrivmedel/1.187129/BiogasificationofLinkopingLTSFINAL.pdf [Accessed 30 July 2011]

312. Park, K. (2004) Cheonggyecheon Restoration Project. Available:http://www.wfeo.org/documents/download/Cheonggeycheon%20Restoration%20Project_%20Korea.pdf. Accessed online: 25 July 2011.

313. Park, K. (2004) Cheonggyecheon Restoration Project. Available:http://www.wfeo.org/documents/download/Cheonggeycheon%20Restoration%20Project_%20Korea.pdf. Accessed online: 25 July 2011.

314. CRP (Cheonggyecheon Restoration Project).(2009) Official website of the Cheong GyeCheon. Available: http://english.sisul.or.kr/grobal/cheonggye/eng/WebContent/index.html. Accessed online: 25 July 2011.

315. GRN (Global Restoration Network). (2007) Case study detail: Restoration of the Cheonggyecheon River in Downtown Seoul. Available: http://www.globalrestorationnetwork.org/database/case-study/?id=123. Accessed online: 25 July 2011.

316. Lee, Y. (2005) Cheonggyecheon Restoration and Urban Development. Available: http://management.kochi-tech.ac.jp/PDF/IWPM/IWPM_Lee.pdf. Accessed online: 25 July 2011.

317. GRN (Global Restoration Network). (2007) Case study detail: Restoration of the Cheonggyecheon River in Downtown Seoul. Available: http://www.globalrestorationnetwork.org/database/case-study/?id=123. Accessed online: 25 July 2011.

318. Lee, Y. (2005) Cheonggyecheon Restoration and Urban Development. Available: http://management.kochi-tech.ac.jp/PDF/IWPM/IWPM_Lee.pdf. Accessed online: 25 July 2011.

319. GRN (Global Restoration Network). (2007) Case study detail: Restoration of the Cheonggyecheon River in Downtown Seoul. Available: http://www.globalrestorationnetwork.org/database/case-study/?id=123. Accessed online: 25 July 2011.

320. CRP (Cheonggyecheon Restoration Project).(2009) Official website of the Cheong GyeCheon. Available: http://english.sisul.or.kr/grobal/cheonggye/eng/WebContent/index.html. Accessed online: 25 July 2011.

321. CRP (Cheonggyecheon Restoration Project).(2009) Official website of the Cheong GyeCheon. Available: http://english.sisul.or.kr/grobal/cheonggye/eng/WebContent/index.html. Accessed online: 25 July 2011.

322. CRP (Cheonggyecheon Restoration Project).(2009) Official website of the Cheong GyeCheon. Available: http://english.sisul.or.kr/grobal/cheonggye/eng/WebContent/index.html. Accessed online: 25 July 2011.

323. CRP (Cheonggyecheon Restoration Project).(2009) Official website of the Cheong GyeCheon. Available: http://

english.sisul.or.kr/grobal/cheonggye/eng/WebContent/index.html. Accessed online: 25 July 2011.

GRN (Global Restoration Network). (2007) Case study detail: Restoration of the Cheonggyecheon River in Downtown Seoul. Available: http://www.globalrestorationnetwork.org/database/case-study/?id=123. Accessed online: 25 July 2011.

324. Lee, Y. (2005) Cheonggyecheon Restoration and Urban Development. Available: http://management.kochi-tech.ac.jp/PDF/IWPM/IWPM_Lee.pdf. Accessed online: 25 July 2011.

CRP (Cheonggyecheon Restoration Project).(2009) Official website of the Cheong GyeCheon. Available: http://english.sisul.or.kr/grobal/cheonggye/eng/WebContent/index.html. Accessed online: 25 July 2011.

325. Park, K. (2004) Cheonggyecheon Restoration Project. Available:http://www.wfeo.org/documents/download/Cheonggeycheon%20Restoration%20Project_%20Korea.pdf. Accessed online: 25 July 2011.

326. Lee, Y. (2005) Cheonggyecheon Restoration and Urban Development. Available: http://management.kochi-tech.ac.jp/PDF/IWPM/IWPM_Lee.pdf. Accessed online: 25 July 2011.

327. Lee, Y. (2005) Cheonggyecheon Restoration and Urban Development. Available: http://management.kochi-tech.ac.jp/PDF/IWPM/IWPM_Lee.pdf. Accessed online: 25 July 2011.

328. Park, K. (2004) Cheonggyecheon Restoration Project. Available:http://www.wfeo.org/documents/download/Cheonggeycheon%20Restoration%20Project_%20Korea.pdf. Accessed online: 25 July 2011.

329. Park, K. (2004) Cheonggyecheon Restoration Project. Available:http://www.wfeo.org/documents/download/Cheonggeycheon%20Restoration%20Project_%20Korea.pdf. Accessed online: 25 July 2011.

330. CRP (Cheonggyecheon Restoration Project).(2009) Official website of the Cheong GyeCheon. Available: http://english.sisul.or.kr/grobal/cheonggye/eng/WebContent/index.html. Accessed online: 25 July 2011.

331. Park, K. (2004) Cheonggyecheon Restoration Project. Available:http://www.wfeo.org/documents/download/Cheonggeycheon%20Restoration%20Project_%20Korea.pdf. Accessed online: 25 July 2011.

332. Park, K. (2004) Cheonggyecheon Restoration Project. Available: http://www.wfeo.org/documents/download/Cheonggeycheon%20Restoration%20Project_%20Korea.pdf. Accessed online: 25 July 2011.

333. CABE (Commission for Architecture and the Built Environment). (2011) Cheonggyecheon Restoration Project: Evaluation. Available: http://www.cabe.org.uk/case-studies/cheonggyecheon-restoration-project/evaluation. Accessed online: 26 July 2011.

334. CABE (Commission for Architecture and the Built Environment). (2011) Cheonggyecheon Restoration Project: Evaluation. Available: http://www.cabe.org.uk/case-studies/cheonggyecheon-restoration-project/evaluation. Accessed online: 26 July 2011.

335. Lee, Y. (2005) Cheonggyecheon Restoration and Urban Development. Available: http://management.kochi-tech.ac.jp/PDF/IWPM/IWPM_Lee.pdf. Accessed online: 25 July 2011.

336. Revkin, A. (2009) Peeling Back Pavement to Expose Watery Havens. New York Times. Available: http://www.nytimes.com/2009/07/17/world/asia/17daylight.html?ref=asia&pagewanted=all. Accessed 25 July 2011.

337. GRN (Global Restoration Network). (2007) Case study detail: Restoration of the Cheonggyecheon River in Downtown Seoul. Available: http://www.globalrestorationnetwork.org/database/case-study/?id=123. Accessed online: 25 July 2011.

338. Revkin, A. (2009) Peeling Back Pavement to Expose Watery Havens. New York Times. Available: http://www.nytimes.com/2009/07/17/world/asia/17daylight.html?ref=asia&pagewanted=all. Accessed 25 July 2011.

339. Revkin, A. (2009) Peeling Back Pavement to Expose Watery Havens. New York Times. Available: http://www.nytimes.com/2009/07/17/world/asia/17daylight.html?ref=asia&pagewanted=all. Accessed 25 July 2011.

340. Kang, C. (2009) Land market impacts and firm geography in a green and transit-oriented city - The case of Seoul, Korea. Ph.D.Dissertation submitted to the Department of City and Regional Planning, University of California, Berkeley, AAT 3410922.

341. CABE (Commission for Architecture and the Built Environment). (2011) Cheonggyecheon Restoration Project: Evaluation. Available: http://www.cabe.org.uk/case-studies/cheonggyecheon-restoration-project/evaluation. Accessed online: 26 July 2011.

342. Kang, C. (2009) Land market impacts and firm geography in a green and transit-oriented city - The case of Seoul, Korea. Ph.D.Dissertation submitted to the Department of City and Regional Planning, University of California, Berkeley, AAT 3410922.

343. CABE (Commission for Architecture and the Built Environment). (2011) Cheonggyecheon Restoration Project: Evaluation. Available: http://www.cabe.org.uk/case-studies/cheonggyecheon-restoration-project/evaluation. Accessed online: 26 July 2011.

344. CABE (Commission for Architecture and the Built Environment). (2011) Cheonggyecheon Restoration Project: Evaluation. Available: http://www.cabe.org.uk/case-studies/cheonggyecheon-restoration-project/evaluation. Accessed online: 26 July 2011.

345. GRN (Global Restoration Network). (2007) Case study detail: Restoration of the Cheonggyecheon River in Downtown Seoul. Available: http://www.globalrestorationnetwork.org/database/case-study/?id=123. Accessed online: 25 July 2011.

346. Cho, M. (2010) The Politics of Urban Nature Restoration, The Case of Cheonggyecheon Restoration in Seoul, Korea. International Development Planning Review, 32(2).

347. GRN (Global Restoration Network). (2007) Case study detail: Restoration of the Cheonggyecheon River in Downtown Seoul. Available: http://www.globalrestorationnetwork.org/database/case-study/?id=123. Accessed online: 25 July 2011.

348. GRN (Global Restoration Network). (2007) Case study detail: Restoration of the Cheonggyecheon River in Downtown Seoul. Available: http://www.globalrestorationnetwork.org/database/case-study/?id=123. Accessed online: 25 July 2011.

349. Revkin, A. (2009) Peeling Back Pavement to Expose Watery Havens. New York Times. Available: http://www.nytimes.com/2009/07/17/world/asia/17daylight.html?ref=asia&pagewanted=all. Accessed 25 July 2011.

About the International Resource Panel

The International Resource Panel (IRP) was established to provide independent, coherent and authoritative scientific assessments on the use of natural resources and its environmental impacts over the full life cycle and contribute to a better understanding of how to decouple economic growth from environmental degradation. Benefiting from the broad support of governments and scientific communities, the Panel is constituted of eminent scientists and experts from all parts of the world, bringing their multidisciplinary expertise to address resource management issues. The information contained in the International Resource Panel's reports is intended to be evidence based and policy relevant, informing policy framing and development and supporting evaluation and monitoring of policy effectiveness. The Secretariat is hosted by the United Nations Environment Programme (UNEP).

Since the International Resource Panel's launch in 2007, six of its assessments have been published. This first series of reports covered biofuels, priority economic sectors and materials for sustainable resource management, metals stocks in society and their rates of recycling, water accounting, and finally the unsatisfactory state of untapped potential for decoupling resource use and related environmental impacts from economic growth.

The assessments of the IRP to date demonstrate the numerous opportunities for governments and businesses to work together to create and implement policies to encourage sustainable resource management, including through better planning, more investment, technological innovation and strategic incentives.

Following its establishment the Panel first devoted much of its research to issues related to the use, stocks and scarcities of individual resources, as well as to the development and application of the perspective of 'decoupling' economic growth from natural resource use and environmental degradation. Building upon this knowledge base, the Panel has now begun to examine systematic approaches to resource use. While technological innovation and efficiency are important they are not sufficient to achieve the required decoupling between economic growth, resource use and emissions. In many cases, efficiency improvements will need to go hand in hand with institutional innovation in activities that have high resource use and emissions. These include the direct and indirect (or embedded) impacts of trade on natural resource use and flows, and the city as a societal 'node' in which much of the current unsustainable usage of natural resources is socially and institutionally embedded. The sustainable management of land and its related resource nexus considerations, land potential and soil quality are also the foci of upcoming reports. In a similar vein it has become apparent that the resource use and requirements of the global food consumption call for a better understanding of the food system as a whole, and in particular its role as a node for resources such as water, land, and biotic resources on the one hand and the varied range of social practices that drive the consumption of food on the other. The years to come will therefore focus on and further deepen these work streams.

About the Cities Working Group

The International Resource Panel (IRP) has as its main mission to provide independent, coherent and authoritative scientific assessments of policy relevance on the sustainable use of resources and their environmental impacts over the full life cycle, and to contribute to a better understanding of how to "decouple" economic growth from environmental degradation.

The Panel's first assessment on "Decoupling" clearly demonstrated that "absolute decoupling" is possible. Innovation and technology development, in principle, could produce 80% reductions in resource and emission intensity in some crucial activities within the housing, food and transport sector. Of course, investing in resource efficiency is necessary but not sufficient for sustainable natural resource use. Because of the scale of the challenge, resource efficiency needs to be complemented by systems sustainability–oriented innovation.

Cities are home to a majority of the world's population, accounting for an estimated 60-80 per cent of global energy consumption, 75 per cent of carbon emissions, 75 per cent of the world's natural resources, and 80% of global GDP. The concentration of resource use and its environment impact is expected to further intensify as urbanization process proceeds. It is clear that many of those opportunities for decoupling are to be found within cities, both retrofitting existing cities and building new ones. This was therefore naturally a key issue for the IRP to explore in more depth.

In late 2010, the Panel established the Cities Working Group with Professor Mark Swilling as the Working Group Coordinator. Members of the International Resource Panel who have also participated in the Cities Working Group include Maarten Hajer, who also takes a leadership role, Walter Pengue and Lea Kauppi.

This first report from the Working Group explores how infrastructure directs material flows and therefore resource use, productivity and efficiency in an urban context. It makes the case for examining cities from a material flow perspective, while also placing the city within the broader system of flows that make it possible for it to function. It also highlights the way that the design, construction and operation of infrastructures create a socio-technical environment that shapes the way of life of citizens and how they procure, use and dispose of the resources they require. The Working Group on Cities will continue to explore the theme of resource use and material flows within an urban context.

About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

- sustainable consumption and production,
- the efficient use of renewable energy,
- adequate management of chemicals,
- the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

- The International Environmental Technology Centre – IETC (Osaka), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.
- Sustainable Consumption and Production (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.
- Chemicals (Geneva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
- Energy (Paris and Nairobi), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
- OzonAction (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
- Economics and Trade (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

UNEP DTIE activities focus on raising awareness, improving the transfer of knowledge and information, fostering technological cooperation and partnerships, and implementing international conventions and agreements.

For more information, see www.unep.org/dtie/

Building upon previous work of the International Resource Panel on Decoupling Natural Resource Use and Environmental Impacts from Economic Growth, this report examines the potential for decoupling at the city level. While the majority of the world's population now live in cities and cities are where most resource consumption takes place, both the pressures and potentials to find ways to reconcile economic growth, wellbeing and the sustainable use of natural resources will therefore be greatest in cities.

Analysing the role of cities as spatial nodes where the major resource flows connect as goods, services and wastes, the report's focus is how infrastructure directs material flows and therefore resource use, productivity and efficiency in an urban context. It makes the case for examining cities from a material flow perspective, while also placing the city within the broader system of flows that make it possible for it to function.

The report also highlights the way that the design, construction and operation of energy, waste, water, sanitation and transport infrastructures create a socio-technical environment that shapes the "way of life" of citizens and how they procure, use and dispose of the resources they require. Its approach is innovative in that it frames infrastructure networks as socio-technical systems, examining pressures for change within cities that go beyond technical considerations. The importance of intermediaries as the dominant agents for change is emphasized, as well as the fact that social processes and dynamics need to be understood and integrated into any assessment of urban infrastructure interventions and the reconfiguration of resource flows.

A set of 30 case studies provide examples of innovative approaches to sustainable infrastructure change across a broad range of urban contexts that could inspire leaders of other cities to embrace similar creative solutions. Of course, innovations in and of themselves do not suffice if they are not integrated into larger strategic visions for the city, and as each city is unique, interventions need to be tailored to the set of challenges and opportunities present in each case.

www.unep.org
United Nations Environment Programme
P.O. Box 30552 Nairobi, 00100 Kenya
Tel: (254 20) 7621234
Fax: (254 20) 7623927
E-mail: uneppub@unep.org
web: www.unep.org

UNEP

For more information, contact:
UNEP DTIE
Sustainable, Consumption and Production Branch
15 rue de Milan
75441 Paris CEDEX 09
France
Tel: +33 1 4437 1450
Fax: +33 1 4437 1474
E-mail: unep.tie@unep.org
www.unep.fr/scp

ISBN: 978-92-807-3298-6
Job Number: DTI /1587/PA