Managing environmental systems: supporting sustainable urbanization

Global urbanization is proceeding rapidly and by 2050 it is projected that two-thirds of the world's people will live in cities, up from approximately half in 2010. The development paths that cities take and how they use resources are therefore critical issues for sustainability.

SEI examines resource use in cities not only under under current conditions but also under different scenarios shaped by demographic and socio-economic trends, climate change, and key policy choices. An important focus is on water resources and sanitation, in both developed and developing countries, while research on climate mitigation, sustainable lifestyles and other issues intersect with and inform this work.

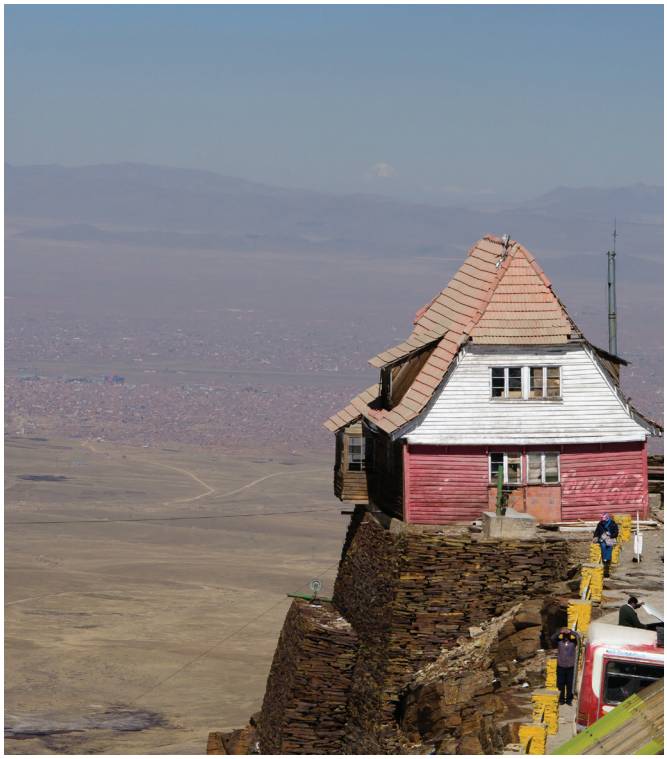
We provide analytical frameworks and data for decision-makers engaged in these issues at the city level. We also place particular emphasis on equity in the urban environment and on the multiple levels of governance and policy (including regional and national) that influence trends and outcomes at local scales. Since 2010 SEI has greatly contributed to scientific knowledge and policy processes in several areas of sustainable urbanization.

Key insights

- ***SEI tools and approaches can reveal the drivers behind trends in water use and supply in urban areas, and show how different factors could affect supply in the short to long term. But, for these methods to be useful, stakeholders need to be involved from the very beginning of the analytical process.***

Since 2010 we have developed new approaches to data collection, data visualization, and participatory decision-making around urban water use and supply, and a cornerstone of this work is our integrated water supply and demand tool, WEAP (Water Evaluation and Planning). The WEAP system is used by thousands of researchers and planners worldwide, and has been translated into 21 languages (see www.weap21.org). Not only do we continually develop and enhance WEAP and support its users, we also extend it by linking it up with an array of other modelling and visualization tools, through research projects and engagement with international funders, national and sub-national governments, and civil society.

Growth in water demand from urban areas is among the greatest drivers of scarcity in both developed and developed-nation settings. Our modelling helps planners understand the severity of the problems they might face, the interplay between urban and agricultural water demands (which are often rising simultaneously), and the implications for both water and energy infrastructure (especially hydropwer). We work with stakeholders and teach them how to use WEAP from the very beginning of the analytical process. This approach builds a sense of ownership and ensures that the resulting models will be accurate and complete, relevant and accessible to stakeholders, and continue to be used after our involvement ends.



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This ski resort above El Alto, Bolivia, is defunct due to glacial retreat, which also affects water supply. SEI works with locals to manage water scarcity.

In one recent project we worked with planners and decision-makers in the cities of La Paz and El Alto in Bolivia to explore solutions to increasing water scarcity and insecurity. In these cities, very rapid urban growth has already pushed water systems to their limit, and climate models show a continuing decline in water supplies as temperatures rise and Andean glaciers recede – even as agricultural water demand increases. SEI developed six possible climate scenarios and projections of their likely impact on local watersheds, testing their vulnerability, resilience and reliability. These scenarios enable local policy-makers to make decisions that are robust and adaptable and can work under a wide range of uncertain futures. The project will not only directly inform water policy and investment choices in the region, but could be a model for cities experiencing similar conditions in South America and beyond (SEI 2013).

- ***SEI analysis shows that the speed at which a city develops (and, in many cases, redevelops) can have a dramatic effect on the carbon footprints of its residents, and that cities can take realistic and cost effective measures to decarbonize.***

We have been at the forefront of research to help cities track greenhouse gas emissions, developing robust frameworks to help them do so. We also focus on the actions that are likely to have the greatest impact – often actions related to transportation systems, land use planning, and energy for buildings. For example, our work in the Seattle area stands as one of the most comprehensive analyses of local-scale GHG emissions to date, and which has proved influential both in the academic literature as well as in

broader dialogues with other actors, e.g., with Local Governments for Sustainability (ICLEI) and C40 Cities about how to measure emissions and assess alternative pathways. We have developed a comprehensive analytical framework for analysing GHG abatement in the world's megacities with the C40 Cities Climate Leadership Group.

The report *The Economics of Low Carbon Cities* was a "mini Stern Review" for the Leeds City Region in the UK (Gouldson, 2013). SEI, alongside the University of Leeds and other partners, developed a robust model for assessing the costs and benefits of different levels of decarbonization at the city region scale. The approach was first applied to the Leeds City Region and the project found that using conservative estimates – compared to 1990 levels – the Leeds City Region could reduce its carbon emissions by 41% by 2022.

- ***To be effective, new sanitation technologies and systems need to engage local people: a sense of ownership among stakeholders is critical, as is analysis and understanding of the economic and social context in which developments take place.***

Sanitation is becoming a water pollution crisis. Currently 75% of wastewater is not treated, and the situation is particularly critical in fast-growing urban and peri-urban areas in developing countries in the light of population growth and increasing water and energy scarcity. Alternatives to waterborne sanitation systems are urgently needed, but need to be fully developed, and SEI is at the forefront of efforts to do so.

SEI was a partner in an effort to introduce a large-scale ecological sanitation system in Erdos, a fast-growing urban area in China. The outcomes of this project underline the key insight above, and a recent book reflects on the work and sets out key lessons that could contribute to the future success of projects of this kind (Rosemarin et al. 2012). We have also developed knowledge and data to support post-2015 international goals, targets and indicators linked to sustainable sanitation, and a 2011 paper has paved the way for new thinking while defining future targets and indicators (Kvarnström et al. 2011).

We have also successfully brought a systems approach to sanitation into national policies, for example in Bolivia, and through regional sanitation agreements like the 2010 Manila Declaration – signed by 13 ministers in East Asia. Sustainable sanitation is now the platform of departure for mainstream discussion at international forums for water and sanitation development, and the concept is now used throughout the UN system. SEI has helped to establish a large international network on sustainable sanitation (SuSanA, the Sustainable Sanitation Alliance), which brings together more than 190 organizations.

- ***Green infrastructure in cities performs a range of key environmental functions, and can also provide a range of co-benefits.***

In an increasingly urbanized world, spaces for nature in cities, including green infrastructure such as green walls, rain gardens and roof gardens, perform a range of important functions, for example mitigating heat islands, insulating buildings, moderating water drainage, reducing flooding and creating habitat for wildlife, including important pollinators.

We are also investigating the co-benefits of urban green space. These include sustaining people's health by building resilience

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A living wall near Victoria station, London, UK. Green architecture can cool the "heat island" effect, insulate buidlings and reduce stress.

to stress and depression (Roe et al. 2013). Also, areas with more green space promote feelings of wellbeing and become more pleasant places to visit, which has knock on effects for business and the local economy, especially in the retail sector, in terms of attracting customers and improving staff morale.

By better understanding and developing positive aspects of the built environment, we aim to influence policy, business investments and land use planning to help create cities that help all people to flourish.

Other major activities

Urban water use

One of our most innovative and high profile recent projects (Mehta 2013) involved visualizing patterns of resource use – principally water – in the burgeoning Indian software capital of Bangalore, mapping its "urban metabolism". We developed preliminary models that illuminate the complex dynamics between surface water supply, groundwater extraction and recharge, and leaking pipes. The project, a partnership with colleagues at the Indian Institute of Management, involves a website that presents the mapping results, an online tool for scenario analysis built with WEAP (see above), and a formal planning process in which local residents and decision-makers are full participants. SEI created an open source "geoportal" to publish Bangalore water data (see www.urbanmetabolism.in) which also includes an online scenario explorer that allows users to interact with a WEAP model for the city. This is the first online deployment of WEAP. The approach is now being extended to Bangkok (see below).

Urban-scale greenhouse gas emissions

Our extensive study of greenhouse gas emissions in the Seattle area stands as one of the most comprehensive analyses of local-scale greenhouse gas (GHG) emissions conducted to date (Lazarus, et al. 2013). We used the study to develop a detailed framework for local governments to track emissions. The approach was published in a prominent scientific journal (Erickson and Lazarus 2012) and informed the primary reporting framework in the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, developed by Local Governments

for Sustainability USA (ICLEI). We also convened a workshop of major Asian cities (Beijing, Shanghai, Bangkok, Jakarta, and Ho Chi Minh City) to focus on low-carbon planning, and published the findings in a report with the World Bank.

Evaluation of opportunities to reduce GHGs in cities has included major assessments of potential reductions in Seattle and Leeds (Gouldson 2012); support for urban transportation analysis in Tallinn and other cities in Estonia; technical support to cities in the UK through the Climate Smart Cities programme; and a broader sustainability impact analysis of the regional plan in Stockholm, Sweden.

Sanitation technologies and systems

Key publications in this area include a reviewed of global trends in the development of urban sanitation systems and explores how menstrual management interacts with those systems (Kjellen 2011). The report is part of a project supported by the Bill & Melinda Gates Foundation.

Microbial Exposure and Health Assessments in Sanitation Technologies and Systems (Stenström 2011) is a major publication summarizing several years' work, complementing the compendium on sanitation systems produced by Sandec/Eawag (Department of Water and Sanitation in Developing Countries at the Swiss Federal Institute of Aquatic Science and Technology). The risk-based work has developed in the context of Safe Sanitation Plans, brought forward at the request of the World Health Organization.

We also provided conceptual advice and knowledge to support the implementation of Bolivia's national policy for dry ecological sanitation. Our input placed a particular emphasis on access, and on monitoring the health risks associated with up-scaling ecological sanitation, particularly in a context where the changing climate has created urgent needs for adaptive solutions.

New research and future pathways

SEI is seeking partnerships to take forward its ongoing work in the WASH & RESCUE project, which is supported by the Swedish Civil Contingencies Agency (MSB). Its aim is to investigate why some urban areas are vulnerable and some are resilient in terms of water, sanitation and hygiene (WASH), and to define what actions are needed to reduce vulnerability. Through new partnerships the aim is to strengthen the link between sanitation, energy production and food security in Brazil, Laos, Vietnam, and China. The focus here is on building more resilient cities through preventive action and risk reduction in sustainable sanitation systems.

The framework of urban metabolism is being extended to Bangkok in 2014, based on experiences in Bangalore (see above). In 2013, SEI invited researchers and representatives of government and the private sector to a scenario-building workshop with the aim of building a joint vision for the city. We are also testing citizen-science initiatives with the aim of filling in key knowledge gaps highlighted through the Bangalore efforts. The exercise aims to provide a statistical snapshot of the complexity of a big city, one that helps us understand "what Bangalore is now", and that can be repeated in bi-annual cycles to track how the city grows. This exercise will serve as a test bed for future data-driven citizen-science initiatives.

In 2014, SEI will also work with its India partners to unravel the water-energy nexus of up to 71 major Indian cities, and to come up with new metrics that could serve as indicators of urban water-energy nexus. SEI will also soon develop an assessment of the GHG abatement potential in the world's cities in association with C40 Cities and Bloomberg Philanthropies, and develop a version of LEAP customized for city-scale analysis. SEI is also conducting analysis to help Tallinn become the European Green Capital. Furthermore, disaster risk reduction in urban areas is one of the core focuses of SEI's new initiative on building resilience to disaster risk.

SEI will do further work on the impacts of green spaces in cities. We are exploring new mobile Electroencephalography (EEG) techniques that measure brain activity on the move to capture stress points in cities, which will help to draw inferences about urban design. We will also continue to investigate how green infrastructure investments benefit people's wellbeing as well as businesses.

This synthesis was written by Tom Gill with contributions from Marion Davis, Peter Erickson, David Purkey and Vishal Mehta.

Collecting water, Bangalore, India. SEI has mapped the "urban metabolism" of India's software capital, and will extend the work to more than 70 other cities.

Further reading

Erickson, P.A., Lazarus, M., Chandler, C. and Schultz, S. (2013). Technologies, policies, and measures for GHG abatement at the urban scale. *Greenhouse Gas Measurement and Management*. doi:10.1080/20430779.2013.806866.

Erickson, P. and Lazarus, M. (2012). Revisiting community-scale greenhouse gas inventories. *Environmental Science and Technology*. 46(9): 4693–94. doi:10.1021/es301366b.

Escobar, M. and Davis, M. (2012). Evaluación De Los Impactos Del Cambio Climático En La Hidrología De Montaña: Desarrollo De Una Metodología a Través De Un Estudio De Caso En Los Andes Del Perú. SEI Policy Brief. SEI, Stockholm. http://www.sei-international.org/publications?pid=2117.

Fogde, M., Macario, L. and Carey, K. (2013). The matter is not if, but when and where? The role of capacity development in disaster risk reduction aiming for a sustainable water supply and sanitation. In: *The Role of Ecosystems in Disaster Risk Reduction*, F. G. Renaud, K. Sudmeier-Rieux, and M. Estrella (eds). United Nations University Press, Tokyo.

Gouldson, A., Kerr, N., Topi, C., Dawkins, E., Kuylenstierna, J. and Pearce, R. (2012). The Economics of Low Carbon Cities: A Mini-Stern Review for the Leeds City Region.

Kjellen, M., Penuslo, C., Nordquist, P., Fogde, M. (2011). *Global Review of Sanitation System Trends and Interactions with Menstrual Management Practices*. Stockholm Environment Institute, Stockholm.

Kvarnström, E., McConville, J., Bracken, P., Johansson, M. and Fogde, M. (2011). The sanitation ladder – a need for a revamp? *Journal of Water, Sanitation and Hygiene for Development*. 1(1). Doi:10.2166/washdev.2011.014

Lazarus, M., Chandler, C. and Erickson, P. (2013). A core framework and scenario for deep GHG reductions at the city scale. *Energy Policy*. 57: 563–74. doi:10.1016/j.enpol.2013.02.031.

Mehta, V. K., Rheinheimer, D. E., Yates, D., Purkey, D.R., Viers, J.H., Young, C.A. and Mount, J.F. (2011). Potential impacts on hydrology and hydropower production under climate warming of the Sierra Nevada. *Journal of Water and Climate Change*, 2(1). 29. doi:10.2166/wcc.2011.054.

Mehta, V.K., Sekhar, M., Kemp-Benedict, E. (2013). Groundwater Impacts of water consumption patterns in Bengaluru, India. Proceedings of the 5th Annual International groundwater Conference, December 2012, Aurangabad, India.

Mehta, V., Goswami, R., Kemp-Benedict, E., Muddu, S., Malghan, D. (2013). Social ecology of domestic water use in Bangalore. *Economic and Political Weekly*, 48. xlviII(15). 40–50.

Roe, J.J., Ward Thompson, C., Aspinall, P.A., Brewer, M.J., Duff, E.I., Miller, D., Mitchell, R., and Clow, A. (2013). Green Space and Stress: Evidence from Cortisol Measures in Deprived Urban Communities. *International Journal of Environmental Research and Public Health*. 10(9), 4086–4103. Doi:10.3390/ijerph10094086.

Rosemarin, A., McConville, J.R., Flores, A.E. and Qiang, Z. (2012). *The Challenges of Urban Ecological Sanitation: Lessons From The Erdos Eco-Town Project*. Practical Action Publishing, Rugby, UK.

SEI (2013). Water Scarcity, Climate Change and Bolivia: Planning for Climate Uncertainties. SEI Policy Brief. Stockholm Environment Institute, Sweden.

Smits, S., Galvis, A., Zambrano, D.A., Herrera, M., Andersson, K. and Bernal, D.P. (2011). *Learning to Work Together on Urban Water Management in the City of Seven Rivers: An Assessment of the SWITCH Project in Cali*. SWITCH Report. http://www.sei-international.org/publications?pid=1983.

Suntura, C. and Sandoval, B. 2012. *Ecological Sanitation in Peri-urban Area of El Alto City, Bolivia*. Sustainable Sanitation Alliance (SuSanA) Case Study. SuSanA, Fundación Sumaj and Stockholm Environment Institute. http://www.susana.org/lang-en/case studies?view=ccbktypeitem&type=2&id=1583.

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