Brief for GSDR – 2016 Update

Green infrastructure: planning for sustainable and resilient urban environment

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Introduction

Cities are an important habitat for an array of physical, economic, social, political and cultural capital. Given this importance, it is significant to think carefully about the nature, operation and form of cities particularly in respect to the challenging issue of sustainability. Cities however, today stand in the face of grave danger in the form of uncurbed urbanization and climate change. As a result of this phenomenon, they are facing problems like biodiversity and natural habitat loss, air pollution exceeding safe limits, and urban flooding.

Climate change is inextricably linked to the process of urbanization where traditional problems like rapid population growth, increasing demand for housing space, need for support infrastructure (especially transport and sanitation)are exacerbated by the demand to accommodate the impacts of climate change in the planning process (Clark, 2009). Responding to these challenges such as unprecedented urban growth lies in innovative development of green infrastructure, which not only ensures resilience, but also includes environmental and well-being benefits. However it is equally significant to manage the development of green infrastructure in order to deliver effective and efficient transition to sustainable urban form that further enhances urban resilience to multiple social, economic and environmental stressors.

Background

Green infrastructure (GI) holds different interpretations for different people. In an urban area, from a social and recreational perspective, it may refer to the trees in the city which provide the necessary 'green' benefits, while from an engineering perspective it may involve the integration of several technical approaches (like swales, green roofs, gardens and parks) applied to

Table 1: Benefits of green infrastructure as mentioned in literature

S.No.	Benefits	Literature Source
1.	Water management	Jacobson (2011), Gill *et al.* (2007), Ellis (2012)
2.	Carbon storage and removal	Velasco and Roth (2010), Davies *et al.* (2011), Nowak *et al.* (2013)
3.	Reduced energy use in buildings	Cameron *et al.* (2012), Qin *et al.* (2012), Jaffal *et al.* (2012)
4.	Air quality improvement	Brantley *et al.* (2013), Freer-Smith *et al.* (2005), Setala *et al.* (2013)
5.	Social benefits	Peschardt *et al.* (2012), Forsyth and Musacchio (2005)
6.	Ecological benefits	Costanza *et al.* (1997), Weber *et al.* (2006)
7.	Human health and well-being benefits	Nordh *et al.*, 2009

facilitate various environmental benefits (See table 1). According to a report by Forest Research (2010), GI can mitigate risks from climate change by protecting urban regions against floods and other negative effects of changing weather patterns (Krause *et al.,* 2011). In addition to the environmental benefits, there are also potential well-being benefits of GI like increased life expectancy,

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better mental and psychological health (Nordh *et al*., 2009).

From a planning perspective the GI approach makes use of the natural environment in a way that it maximises its functions and seeks to put in place, either through regulatory or planning policy, mechanisms that ensure protection of natural environment, and proposes how these can be put in place through landscaped and/or engineered activities (Benedict and McMahon, 2006). However the planning approach differs from region to region. The concept of GI in European countries refers to the new or existing interlinked networks or corridors of green routes and hubs of biodiversity (Murphy, 2009), which is recognised as a valuable approach for spatial planning and is now seen in national, regional and local planning and policy documents and strategies (Lafortezza *et al.,* 2013). On the other hand, USEPA (United States Environmental Protection Agency) lays emphasis on the protection of natural habitat in both urban and rural areas through GI (2009). This concept follows the general approach by introducing facilities such as parks, gardens, swales into the urban infrastructure and is managed by USEPA and partner organizations in different municipality areas (Weinstein, 2008).

While US and Europe both lay emphasis on the role of public bodies in planning approaches, Singapore encourages other stakeholders—landowners, private developers to incorporate green features into their developments, and the community to embrace green infrastructure for recreational & educational purposes, in addition to its environmental value (Public Utilities Board, 2013).

The Problem

In an urban context, mounting levels of urbanization creates a network of barriers that result in a patchwork of land uses and isolated open space areas. Consequently natural ecosystems become scattered across the landscape and displaced by new land-use developments (Geneletti, 2004; Lafortezza *et al.,* 2008). Improving the functional and spatial connectivity of these landscapes is a prerequisite to its ability to mitigate and adapt to climate change and in turn to increase the value of the goods and services that ecosystems provide (Grimm *et al.,* 2008; Hodgson *et al.,* 2009) thereby moving towards achieving urban sustainability. A solution to this challenge lies in developing GI approach that considers the landscape as an overall blanket of inter-related ecosystems in which single components interact with each other through a multitude of elements (Weber *et al.,* 2006).

However, GI differs from other approaches in landscape planning because it considers ecological and social values in combination with other land use developments (Aegisdóttir *et al.,* 2009). Planning of green infrastructure here refers to policies and planning activity affecting urban GI, in particular through processes of land use and management and development of nature areas and elements. As mentioned previously, there is a variety of national and local planning cultures and needs present, due to which no single definition of green infrastructure planning exists, but instead a set of shared principles have been developed as guidance for different contexts (Pauleit *et al.*, 2011), which makes it increasingly difficult for experts to come up with a consistent strategy towards managing urban GI.

The Solution

It is widely known that in order to deal with the impacts of climate change, urban systems of infrastructure need to be both sustainable, that is, be able to thrive without excessive reliance on external resources and resilient, to be able to prevent and recover from distress and cope from challenging issues. Cities are often considered to be centres of knowledge and innovation and the challenge in building resilient cities lies in how they are managed and developed. It is where the role of different actors comes in view as these actors act as leaders to deal with multiple issues related to climate change, environmental degradation and social-economic turmoil, and can be considered as potential drivers for urban resilience. Literature often cites that urban sustainability can be achieved by managing change or transition that directs development in cities (see Loorbach, 2007), where sustainable development works as a strategic tool that brings together a series of interests and stakeholders in the planning and development process, which is no different for GI.

Similarly, the effective development of GI approaches takes place through a co-ordinated action between decision-makers and other relevant stakeholders ensuring the proper translation of policy (usually formulated at national level) into practice (implemented at regional or local level) (Mell, 2013). This can be achieved through a shift in the political landscape, from a centralized institution to a more liberal, market-based structure and incorporation of the concept of "multi- actor governance" which push towards new forms of bottom-up ruling styles and a break from dominant approaches (Loorbach, 2010). However, in the context of GI the unclear role of all these actors and the collaboration between them (especially any kind of public private partnership for green infrastructure development) has not been effectively examined through academic research, and requires further study, especially in case specific approaches, since there is a lack of standard guidance for doing so. Therefore, academics must focus on studies that will address this issue, by looking at the planning of GI approaches especially with respect to the role of state and non-state actors in facilitating the effective development and implementation of such an approach[1].

References

Aegisdóttir HH, Kuss P, Stöcklin J (2009). Isolated populations of a rare alpine plant show high genetic diversity and considerable population differentiation. *Annals of Botany* 104: 1313-1322

Benedict, M., & McMahon, E. (2006). *Green infrastructure: Linking landscapes and communities*. Washington, DC: Island Press

Brantley, H., Hagler, G., Deshmukh, P., Baldauf, R. (2013). Field assessment of the effects of roadside vegetation on near-road black carbon and particulate matter. *Science* of the *Total Environment*. 468-469: 120-129

Cameron, R., Blanusa, T., Taylor, J., Salisbury, A., Halstead, A., Henricot, B., Thompson, K. (2012). The domestic garden e its contribution to urban green infrastructure. *Urban* Forestry *and Urban* Greening. 11 (2): 129-137

Clark, A. L. (2009). Environmental challenges to urban planning: Fringe areas, ecological footprints and climate change. In *Proceedings of the Key Challenges in the Process of Urbanization in Ho Chi Minh City: Governance, Socio-economic and Environmental Issues.* Ho Chi Minh City: Institute for Development Studies

Costanza R, d'arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'neill RV, Paruelo J, Raskin RG, Sutton P, van den Belt M. (1997). The value of the world's ecosystem services and natural capital. The

[1] The author is currently researching the issue by undertaking the case study of Delhi (India) as a part of her Ph.D. project. Brief summary can be found here: http://www.dlgs-dresden.de/stipendiaten-und-stipendiatinnen/shikha-ranjha/

value of the world's ecosystem services and natural capital. Nature 387 (6630): 253-260

Davies, Z., Edmondson, J., Heinemeyer, A., Leake, J., Gaston, K. (2011). Mapping an urban ecosystem service: quantifying above-ground carbon storage at a citywide scale. Journal of *Applied Ecology*. 48 (5): 1125-1134

Ellis, J. (2012). Sustainable surface water management and green infrastructure in UK urban catchment planning. *Journal* of *Environmental Planning* and *Management*. 56 (1): 24-41

Forest Research (2010). *Benefits of green infrastructure*. Report by Forest Research, Contract no. WC0807, Farnham, UK

Forsyth, A. & Musacchio, L. R. (2005). Designing Small Parks: A Manual for Addressing Social and Ecological Concerns. John Wiley & Sons, Canada

Freer-Smith, P., Beckett, K., Taylor, G. (2005). Deposition velocities to Sorbus Aria, Acer Campestre, Populus Deltoides X Trichocarpa 'Beaupre', Pinus Nigra and X Cupressocyparis Leylandii for coarse, fine and ultra-fine particles in the urban environment. *Environmental Pollution*. 133: 157-167

Geneletti D (2004). Using spatial indicators and value functions to assess ecosystem fragmentation caused by linear infrastructures. International Journal of Applied Earth Observation and Geoinformation 5: 1-15

Gill, S., Handley, J., Ennos, A., Pauleit, S. (2007). Adapting cities for climate change: the role of the green infrastructure. *Built Environment*. 33 (1): 115-133

Grimm NB, Foster D, Groffman P, Grove JM, Hopkinson CS, Nadelhoffer KJ, Pataki DE, Peters DP (2008). The changing landscape: ecosystem responses to urbanization and pollution across climatic and societal gradients. *Frontiers in Ecology and the Environment* 6: 264-272

Hodgson JA, Thomas CD, Wintle BA, Moilanen A (2009). Climate change, connectivity and conservation decision making: back to basics. *Journal of Applied Ecology* 46: 964-969

Jacobson, C.R. (2011). Identification and quantification of the hydrological impacts of imperviousness in urban catchments: a review. *Journal of Environmental Management*. 92 (6): 1438-1448

Jaffal I, Ouldboukhitine S, Belarbi R. (2012). A comprehensive study of the impact of green roofs on building energy performance. *Renewable Energy* 43:157–64

Krause B, Culmsee H, Wesche K, Bergmeier E, Leuschner C, (2011). Habitat loss of floodplain meadows in north Germany since the 1950s. *Biodiversity and Conservation* 20: 2347-2364

Lafortezza R, Corry RC, Sanesi G, Brown RD (2008). Visual preference and ecological assessments for designed alternative brownfield rehabilitations. *Journal of Environmental Management* 89: 257-269

Lafortezza, R., Davies, C., Sanesi, G., Konijnendijk, C.C. (2013). Green Infrastructure as a tool to support spatial planning in European urban regions. *iForest* 6: 102–108.

Loorbach, D. (2007). *Transition management, new mode of governance for sustainable development*. Utrecht, the Netherlands: International Books

Loorbach, D. (2010). Transition management for sustainable development: a prescriptive, complexity-based framework. *Governance: An International Journal of Policy, Administration, and Institutions* 23(1): 161–183

Mell, I.C. (2013). Can you tell a green field from a cold steel rail? Examining the 'green' of Green Infrastructure Development. *Local*

Environment: The International Journal of Justice and Sustainability 18 (2): 152-166

Murphy, P. (2009). Green infrastructure for Europe? View from the commission, Proceedings in the European commission workshop, 25–26 March 2009, Brussels

Nordh, H., Hartig, T., Hagerhall, C. M. & Fry, G. (2009). Components of small urban parks that predict the possibility for restoration. Urban Forestry & Urban Greening, 8: 225-235

Nowak, D., Greenfield, E., Hoehn, R., Lapoint, E. (2013). Carbon storage and sequestration by trees in urban and community areas of the United States. Environmental Pollution. 178: 229-236

Pauleit, S., Liu, L., Ahern, J., Kazmierczak, A. (2011). Multifunctional Green Infrastructure Planning to Promote Ecological Services in the City. In Niemelä, J., Breuste, G., Guntenspergen, N., McIntyre, T., Elmqvist, T., James, P. (Eds.), *Urban ecology: Patterns, Processes, and Applications*. Oxford University Press, Oxford, 272–285

Peschardt, K., Schipperijn, J. & Stigsdotter, U. K. (2012). Use of Small Public Urban Green Spaces (SPUGS). Urban Forestry & Urban Greening, 11: 235-244

Public Utilities Board. (2013). ABC Waters Design Guidelines. Available: http://www.pub.gov.sg/abcwaters/abcwatersdesignguidelines/Pages/ABCDesignGuidelines.aspx. Accessed : 10th August, 2015

Qin X, Wu X, Chiew YM, Li Y. (2012). A green roof test bed for stormwater management and reduction of urban heat island effect in Singapore. *British Journal of Environment and Climate Change* 2(4):410–20

Setala, H., Viippola, V., Rantalainen, A.-L., Pennanen, A., Yli-Pelkonen, V., (2013). Does urban vegetation mitigate air pollution in northern conditions? *Environmental Pollution* 183: 104-112

USEPA. (2009). *Water Quality scorecard: incorporating green infrastructure practices at the municipal, neighborhood, and site scales*, United States Environmental Protection Agency, Washington DC

Velasco, E., Roth, M. (2010). Cities as net sources of CO2: review of atmospheric CO2 exchange in urban environments measured by Eddy covariance technique. *Geography Compass* 4 (9): 1238-1259

Weber T, Sloan A, Wolf J. (2006). Maryland's Green Infrastructure assessment: development of a comprehensive approach to land conservation. *Landscape and Urban Planning* 77 (1-2): 94-110

Weinstein N. (2008). *LID observations*, Low Impact Development Center, May 2008