

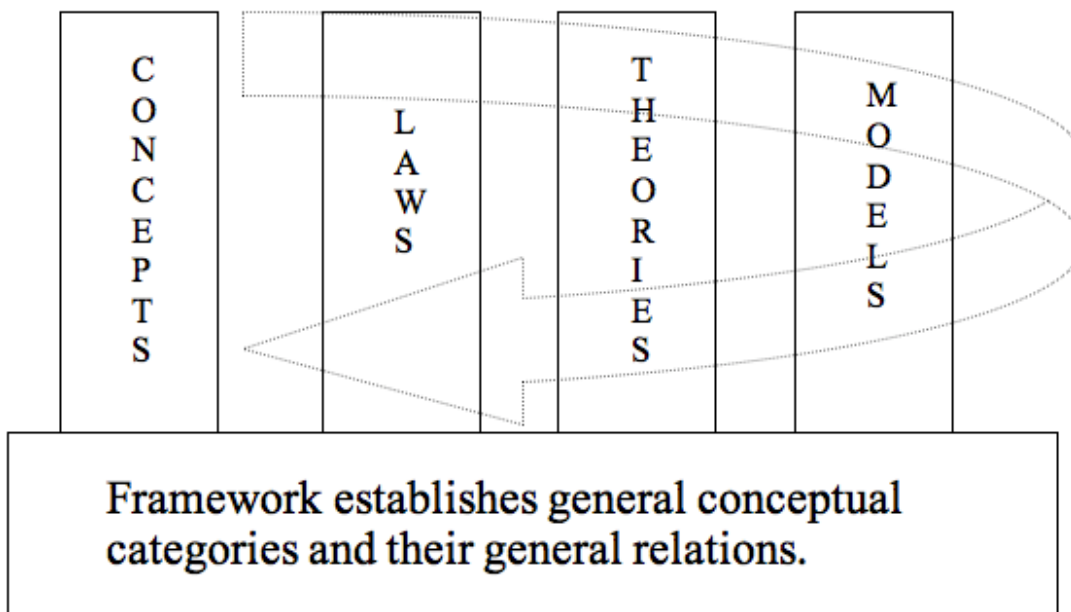
**SUPPORTING INFORMATION FOR:**

Ramaswami, A., C. Weible, D. Main, T. Heikkila, S. Siddiki, A. Duvall, A. Pattison, and M. Bernard. 2012. A Social-Ecological-Infrastructural Systems framework for interdisciplinary study of sustainable city systems: An integrative curriculum across seven major disciplines. *Journal of Industrial Ecology*.

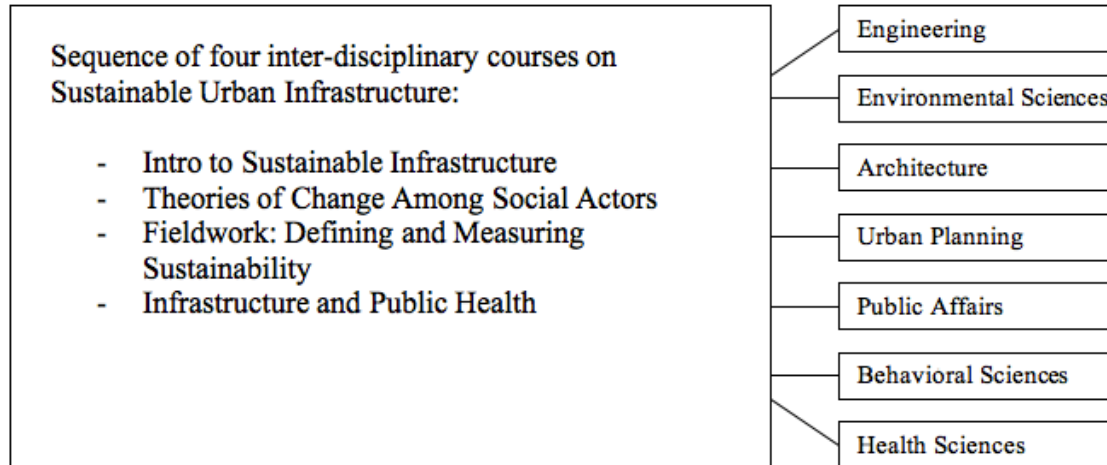
**Summary**

This supporting information consists of four figures and a table. The first figure depicts the key elements of effective frameworks. The remaining 3 figures provide information about the sustainable urban infrastructure program at the University of Colorado Denver (UCD): integration of interdisciplinary courses on sustainable urban infrastructure into graduate programs at UCD; student enrollment across multiple disciplines in the program; and student learning of various social-ecological infrastructural systems concepts. The table shows concepts covered in the introductory course on sustainable urban infrastructure, organized by module with supporting resources.

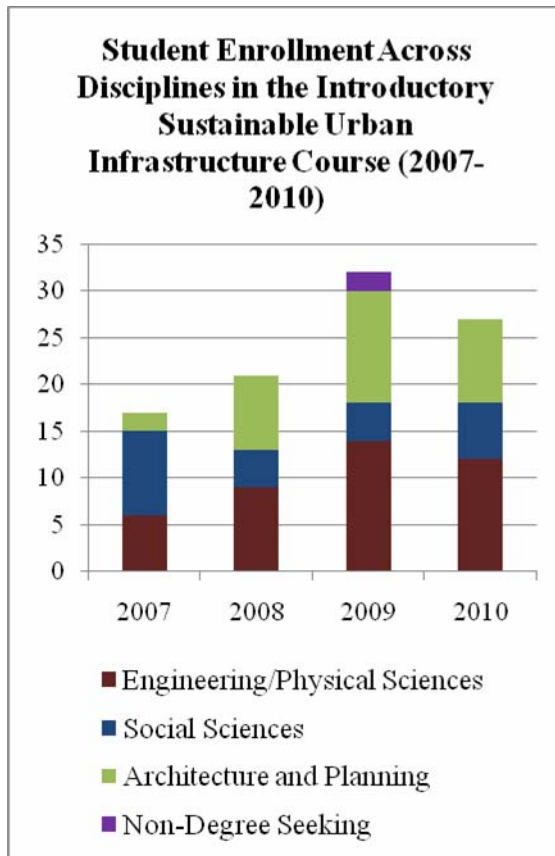
**Figure S1:** Key elements of effective frameworks



**Figure S2:** Curriculum design: Integration of a sequence of four interdisciplinary courses on Sustainable Urban Infrastructure into graduate programs in seven major disciplines.

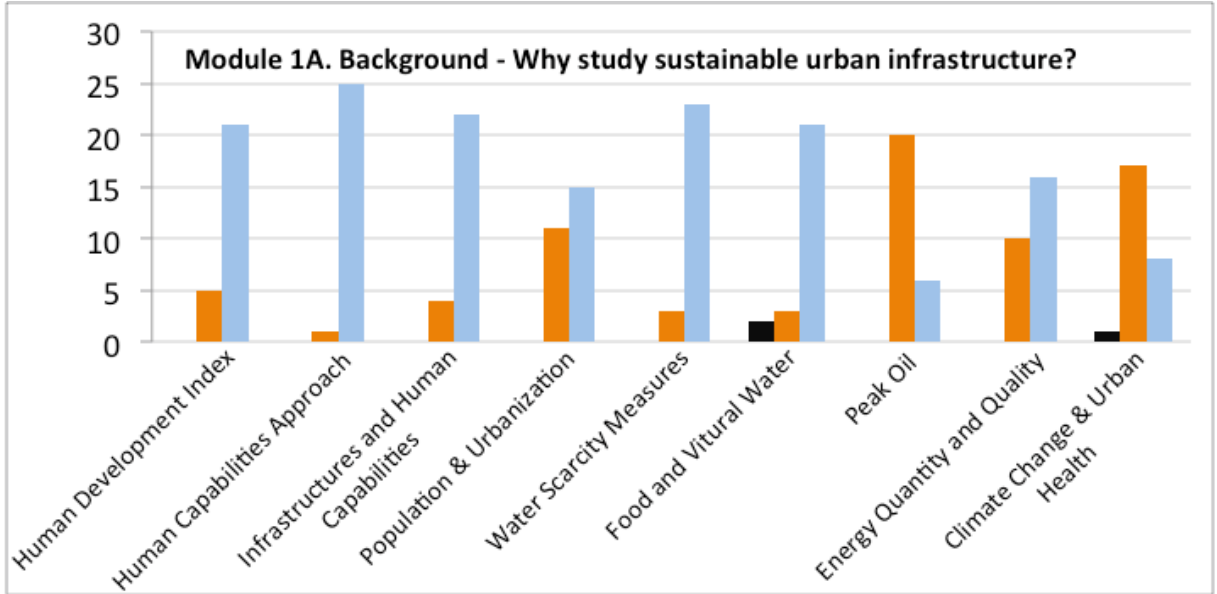


**Figure S3:** Student enrolment across multiple disciplines in a broadly-based graduate program on sustainable urban infrastructure at UC Denver.



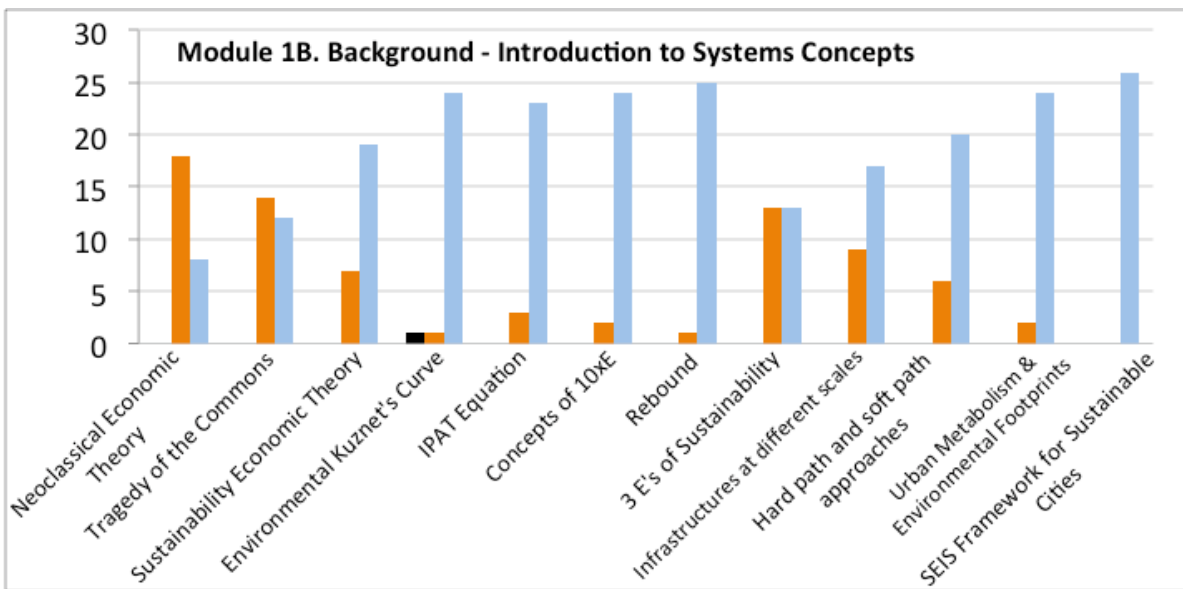
**Figure S4:** Number of students (total class size, n=26) and their exposure to various concepts covered in the introductory course on Sustainable Urban Infrastructure via the inter-disciplinary SEIS curriculum (blue bar) versus their home discipline/outside academia (orange bar). Concepts are organized in modules 1a-b, 2 and 3.

a)

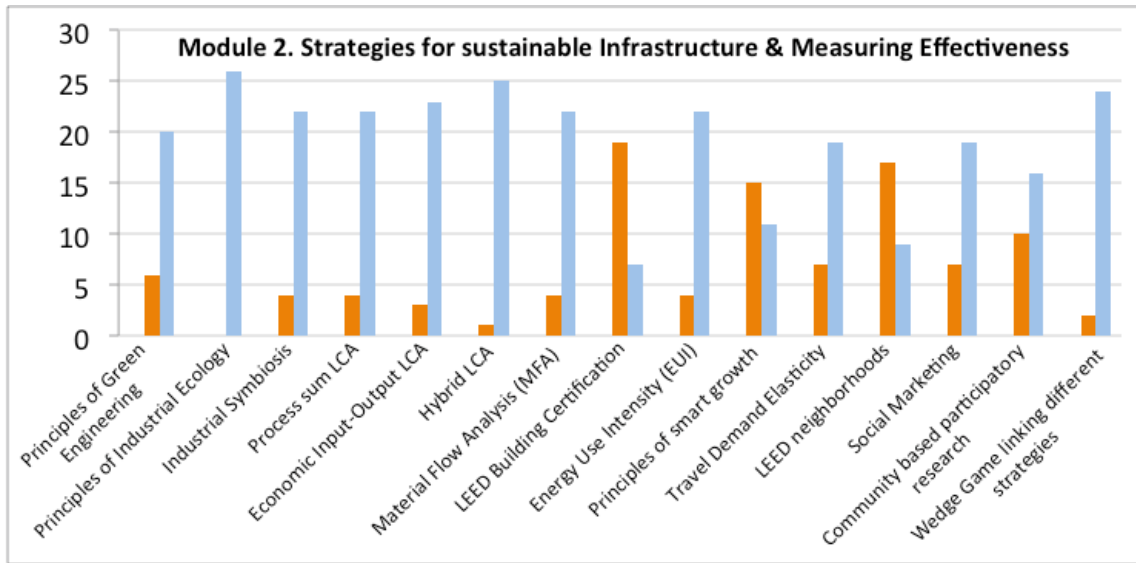


b)

- No Idea what this concept is about.
- Learned this concept in home discipline and/or outside school.
- Learned this concept in current or prior interdisciplinary IGERT course.

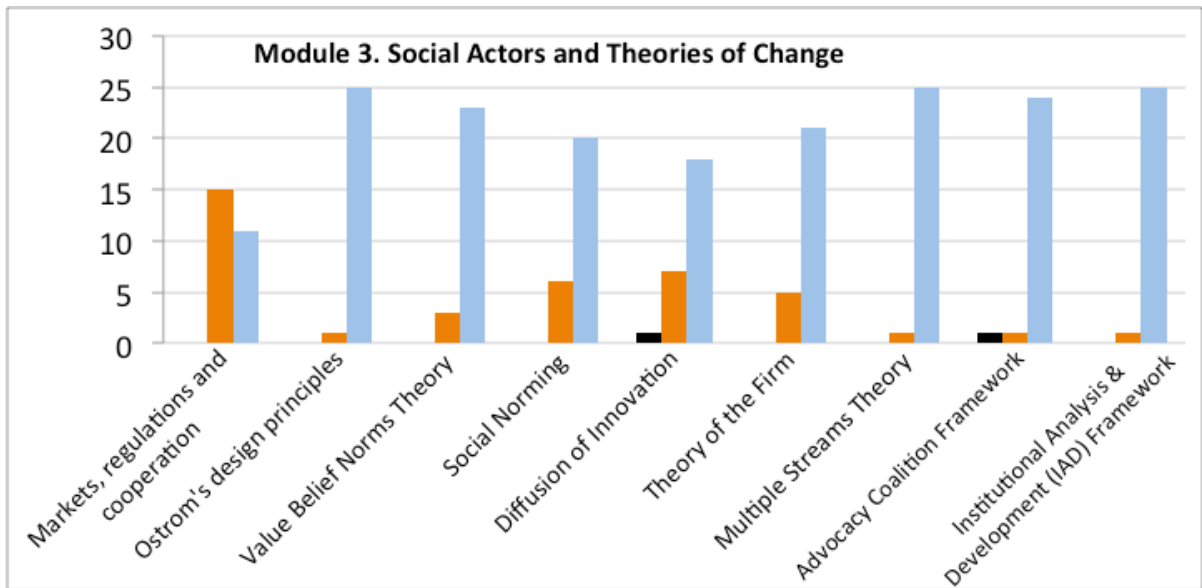


c)



- No Idea what this concept is about.
- Learned this concept in home discipline and/or outside school.
- Learned this concept in current or prior interdisciplinary IGERT course.

d)



**Table S-1:** Concepts covered in the introductory course on Sustainable Urban Infrastructure, organized by module and with supporting resources.

Concept	Resource/Readings
<b>MODULE 1A. BACKGROUND - WHY STUDY SUSTAINABLE URBAN INFRASTRUCTURE?</b>	
Human Development Index	Fukuda-Parr (2003); Haq (2003)
Human Capabilities Approach	
Infrastructures and Human Capabilities (with focus on energy)	Steinberger and Roberts (2010)
Population Growth & Urbanization	Bartlett (2007) – Video
Water Scarcity Measures	Gleick (1996); Rijsberman (2006)
Food and Virtual Water	IWMI (1995) – Visual (maps)
Peak Oil	ASPO (2012); Bartlett (2007)
Energy Quantity and Quality	Lovins (1977)
Infrastructure, Climate Change & Urban Public Health	Cambell-Lendrum (2007); WHO (2009)
<b>MODULE 1B. BACKGROUND - INTRODUCTION TO SYSTEMS CONCEPTS</b>	
Neoclassical economic theory (review)	Hackett (1998)
Tragedy of the Commons	Hardin (1968); Dietz et al. (2003)
Sustainability economic theory	Daly (2005)
Environmental Kuznet's Curve	Chertow (2001)
IPAT Equation	
Concepts of 10xE	Gotttron (2001)
Rebound	
3 E's of sustainability and local context	Jamieson (1998); Mebratu (1998)
Infrastructures at different scales	In-Class Discussion
Hard path and soft path approaches	Gleick (2003); Lovins (1977)
Urban Metabolism & Environmental Footprints	Wolman (1965); Kennedy (2007); Ramaswami et al. (2008)
SEIS Framework for Sustainable Cities	Ramaswami et al. (2012)- this paper
<b>MODULE 2. STRATEGIES FOR SUSTAINABLE INFRASTRUCTURE &amp; MEASURING EFFECTIVENESS</b> <b>[Strategies are drawn from multiple disciplines]</b>	
Technology Strategy: Green Engineering	Anastas and Zimmerman (2003)
Technology Strategy: Industrial Ecology	Ehrenfeld and Gertler (1997)
Technology Strategy: Industrial Symbiosis	
- Measurement - Process sum LCA	NREL (2011), ANL (2011)
- Measurement – EIO LCA	CMU (2008)
- Measurement - Hybrid LCA	Ramaswami et al. (2008)
- Urban MEFA & Footprint Calculation	Ramaswami et al.(2008)
Green Building Design Principles (Arch)	USGBC (2011)
- Measurement of Energy Use Intensity	Turner and Frankel (2008)
Smart growth strategies (Urban Planning)	EPA (2011)
- Measurement Travel Demand Elasticity	NRC (2009)
- LEED Neighborhood Design	USGBC (2011)
Public Policy Strategies: Markets, Regulations and Cooperation	Hackett (1998)
Community Engagement Strategies	McKenzie-Mohr & Smith (2010); Israel et al. (1998)
- Social Marketing	
- Community-based Participatory Research	
GHG Mitigation Wedge Game	Pacala and Socolow (2004)
- GHG Mitigation Wedge Case Study of Denver linking social system and biophysical system strategies	Ramaswami et al. (2012)

MODULE 3. SOCIAL ACTORS AND THEORIES OF CHANGE	
Ostrom’s design principles; - Bali Rice Farming Case Study	Dietz et al. (2003); Ramaswami et al. (2007)
Value Belief Norms Theory	Stern (2000)
Social Norming; - OPOWER and Hotel Case Study	Schultz et al. (2007); OPOWER (2011); Goldstein et al. (2008)
Diffusion of Innovation	Rogers (2003)
Theory of the Firm; - ENERGY STAR Case Study	Howarth et al. (2000)
Multiple Streams Theory- - Cap and Trade Case Study	Brunner (2008)
Advocacy Coalition Framework	Sabatier (1988)
Institutional Analysis & Development (IAD) Framework	Ostrom (1990); Hackett (1998)
INTEGRATION ACROSS MODULES	
Integration occurs via group projects assigned to the class that focus on any one infrastructure sector. A case study of the transportation sector is used in-class and in homework problems to connect the different modules. The case study delineates the different strategies toward more sustainable transportation systems, described field measurements of their effectiveness, and identifies different actors/actors behaviors that are important in implementing each strategy. All the strategies are evaluated together quantitatively using the GHG mitigation wedge to ascertain highest impact strategies that are likely to be most politically feasible/socially acceptable.	

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