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Review

Recent progress on innovative urban infrastructures system towards sustainable resource management

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ABSTRACT

Urban infrastructure, as the interface between the socioeconomic activities and natural resources/build environment, is critical to sustainable resource management at urban scale. To address various emerging challenges and capture opportunities for urban transition from an infrastructure system innovation perspective, this Special Issue ("Urban infrastructures system for sustainable resource management") of the journal <*Resources, Conservation & Recycling*> highlighted recent progress on characterizing the sustainability of infrastructure system towards sustainable urban development and resource management, based upon comprehensive reviews, regenerative urban infrastructures development and urban industrial symbiosis, novel and integrated planning and evaluation tools/methods, and the innovative policies. The 21 articles in this SI showed that tangible socioeconomic and environmental benefits were able to be achieved from innovation on urban infrastructures system. The results and recommendations provided critical insights on how to promote innovative urban infrastructure development within different contexts. Via reviewing on the articles in this SI, an integrated framework for future research concerns and implications on promoting sustainable urban infrastructure planning and management is proposed, so as to create the synergies for addressing urban and regional environmental quality and impacts, and methods to track the ever-improvements through the established research framework.

1. Introduction

There is no doubt that urban sustainability is critical for sustainable development (SD) strategy, with the fact that cities are already responsible for most of the global environmental footprints of carbon and resources and accommodate more than half of the world's population (Dong et al., 2013; Kennedy et al., 2009, 2011). Studies reported that: "Even with the most optimistic projections of future innovation on technological solutions, it's difficult to reach the 2050 target of 50% less CO_2 emissions, due to increasing demand for human being's societal development" (Allwood et al., 2010; Kennedy et al., 2011). Hence, innovative and systematic solutions are required to strengthen urban sustainability under the challenges like climate change, resource efficiency and environmental footprints minimization (Dong et al., 2016; Fujii et al., 2016).

Urban infrastructures play a crucial role in urban sustainability, as "physical social well being" and interface between the socioeconomic activities and natural resources/build environment (EU, 2013). Therefore, it should be given special attention as the development of infrastructures system usually has to face interleaving socioeconomic, environmental and ecological challenges, such as complex interaction of urban and industrial metabolism, resilience to climate change, comprehensive urban environmental management, and local oriented practical implementation (Hostetler et al., 2011; Pandit et al., 2015). With this circumstance, building optimal infrastructures system for the economy and life in cities requires environmental friendly infrastructures design and spatial planning, taking account of the related urban socioeconomic metabolism, life cycle impacts, land use optimization and innovative management scheme. Particularly, emerging industrial ecology and urban ecology tools and approaches enable to address the new challenges on exploring symbiotic ways to design the urban infrastructure systems; optimizing the underlying materials and energy metabolism of cities to mitigate environmental footprints; and developing innovative decision support tools (Dong et al., 2014; NILIM, 2012; Xu et al., 2012). However, to date, existing studies have not addressed such topics well enough.

With this circumstance, this special issue (SI) "Urban infrastructures system for sustainable resource management" included the state of the art studies on comprehensive reviews and innovative design and planning on urban infrastructures, emerging engineering technologies, holistic analytical tools and databases, decision making methods, implementation strategy/business model, as well as cost-effective policy implications for promoting sustainable and green urban infrastructures design. In total 21 articles were accepted into this SI.

In order to introduce the readers to this SI, in this review paper, the editorial team clustered the papers according to the themes

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described in our initial Call-for-Papers, and further offered critical highlights and lessons from the accepted papers. We summarized the and organized the key findings and insights as follows: after this introduction section, Section 2 presented papers related to "comprehensive reviews"; Section 3 reviewed papers within the topic of "regenerative urban infrastructures development and urban industrial symbiosis", Section 4 summarized papers on "planning and evaluation tools", Section 5 reviewed the "Decision support tools and innovative policies". Finally, based on the critical findings, we proposed and discussed the concluding remarks on research framework and future concerns on promoting sustainable urban infrastructure planning and management.

2. Comprehensive reviews

As an enlightening summary on current progress on studies under the theme of urban infrastructures, Ferrer et al. (2017) provided a systematic literature review via bibliographic analysis on 995 existing studies. With investing on keywords and their co-occurrence; two critical research questions were studied; including the hotspot themes for sustainable urban infrastructure studies; and the evolution of such research topics. The prevailing topics contained concerns on infrastructures regeneration (e.g.; stormwater); environmental impacts and their analytical tools (e.g.; climate change; life cycle analysis); resilience of urban infrastructures system (e.g.; vulnerability); and emerging concerns on developing countries; in line with the fact that they were experiencing rapid urbanization and the infrastructures construction. The findings of this paper offered a critical overview on the future research agenda on urban infrastructures. Wu et al. (2017a) applied an improved Data Envelopment Analysis (DEA) model to analyze the construction efficiencies of urban water treatment infrastructures in China's 70 megacities in the period of 2006–2012. Based on such quantitative results; critical review could be gain on the construction conditions; cost-benefits (efficiency) and policies implication for the main cities in China; for the improvements of their water infrastructures. Woltersdorf et al. (2017) presented the study on the identification on benefits and challenges of various urban nutrient and water reuse systems; which were important format of urban infrastructures symbiosis as nature-based solutions for urban development. Method integrating multi-decision criteria analysis with the Analytic Hierarchy Process (AHP) was applied to identify and compare the multiple criteria of various systems; from the ecological; economic; societal; institutional; political; and technical perspectives. The findings and summaries were helpful to the urban planners and decision makers to design; plan; construct and renew the urban agriculture system and related infrastructures with optimal equilibrium benefits.

3. Regenerative urban infrastructures development and urban industrial symbiosis

The discipline of industrial ecology, urban ecology and the practice of eco-industrial development provided an innovative pathway to regenerative urban development and its infrastructures planning, construction and renewal, by exploring the symbiotic way of infrastructures development, urban industrial symbiosis and nexus transition of urban metabolism. Papers highlighting such concepts and diversified practices were selected for this section.

Innovative energy and related infrastructures symbiosis strongly support the fight to climate change and enhance urban energy and resource efficiency. Ohnishi et al. (2017) presented the model practice of waste to energy symbiosis in Japan, as well as the proposed analytical model for cost-benefit assessment on the energy recovery options. Via various designed scenarios, including isolate recovery technologies, symbiotic system such as heat utilization between the incineration plant and fermenter, and urban symbiosis option like refuse paper and plastic fuel (RPF), the optimal energy efficient options were identified, which provided critical insights on low-carbon city promotion in Japan and the world. Dou et al. (2017) provided the other innovative practice of symbiotic design on energy infrastructures with spatial analysis, in Fukushima prefecture, as a key regenerative strategy in the "post Fukushima era". In this study, enlightened from urban industrial symbiosis, district heating using waste heat from industries was proposed and designed for one recovery region in Fukushima, named Shin-chi town, and an assessment system was developed with land use scenario analysis to quantitatively evaluate the impacts from land use design on the economic feasibility and CO_2 emission reduction of heat exchange. Results indicated that positive guidance towards compact and mixed land use, including concentrating residential houses and locating facility agriculture near industrial park, would significantly improve the performance on energy saving and CO_2 reduction, meanwhile reducing investment cost of infrastructure.

Eco-industrial parks (EIPs) is one of the key practice of urban industrial symbiosis and being prevailingly promoted all over the world. Particularly, China, South Korea and Japan all launched national EIP program to support their regional eco-industrial development. Liu et al. (2017) compared the EIPs development and related policies implications and impacts in China and Canada, with case studies in selected specific EIP, named Tianjin Economic Development area (TEDA), which among the most famous ones in China, and Burnside Industrial Park, which was regarded as one of the largest park in Canada. Policies to forward their development and evolution from industrial parks to EIPs were analyzed systematically and summarized enlightening insights for the EIPs promotion in both developed and developing countries.

Finally, urban agriculture (UA) offers the other important practice of urban symbiosis, with linkage between urban areas and natural system, providing a nature-based solution to inclusive urban regeneration. Wielemaker et al. (2017) studied innovative and emerging urban agriculture system with source-separation-based new sanitation in Rotterdam, The Netherlands, with provision of an designing and analytical approach, based on urban harvest approach which enabled to analyze urban nutrient flows and related urban metabolism.

4. Planning and evaluation tools

From an infrastructure ecology point of view, urban infrastructures are somehow analogous to ecological systems in term of their interaction, and with exchange of material and energy flows among themselves and to and from the environment. Hence to analyze them together as a whole provides a better understanding of their dynamics and interactions, and enables system-level optimization. As a result, it requires multiple tools including urban metabolism approaches, including LCA, material flows and stock analysis, and input-output analysis; nexus evaluation methods and spatial planning tools, as well as their integration. It will therefore support decision for infrastructures planning and construction, as well as the underlying resource management.

LCA tools and databases construction is highlighted as a research hotspot for urban infrastructures. Goulart Coelho and Lange (2017) investigated the waste management in Brazil with the application of LCA approach, in the case city named Rio de Janeiro. This research was highlighted as an complementary information to the LCA application in developing countries within the topic of integrated waste management. Via the LCA analysis on various scenarios, suggestions on the more environmentally friendly and sustainable MSW

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