

Research Paper

Ecosystem services management: An evaluation of green adaptations for urban development in Dhaka, Bangladesh

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ABSTRACT

We evaluated green adaptation strategies (parks, gardens, green roof, rainwater harvest, green façades/wall, porous pavement, and green and blue belts) in the context of urban development and potential climate change impacts for the city of Dhaka, Bangladesh. Our review of relevant literature revealed substantial environmental (cooler and cleaner environment), economic (reduced energy demand, avoided cost of drainage maintenance, increased land values) and social (higher social interaction, improved mental and physical health) benefits arising from the maintenance and development of ecosystem services in major cities. Our evaluation of green adaptation strategies was undertaken with household surveys in three wards of Dhaka, expert interviews, and our personal experiences. Rooftop gardens/agriculture had very high social acceptance (85%) and economic feasibility and was commonly practiced in Dhaka, particularly among house owners. Pocket park, green roof, rainwater harvest, green façades/wall, porous pavement, and community garden were all considered to be highly feasible for implementation with collective efforts but had lower social acceptance. Many respondents were unwilling to pay for green adaptation strategies even knowing their benefits. Our research revealed that successful implementation of beneficial green adaptation will require public participation at all stages supported through awareness raising campaigns. Enforcement of laws and strong commitment from the government was also considered to be beneficial. However, more transparent cost-benefit analyses promoting the conservation of ecosystem services is required, particularly for resource-poor Dhaka. Green adaptations make cities more resilient to pressures from demographic change and climate change increasingly relevant in the developing world.

1. Introduction

More than half of the world's population (54%) live in urban settings and this is expected to increase to 66% by 2050 (United Nations, 2014). Urbanization is problematic in developing countries (Khadka & Shrestha, 2011; Rana, 2011) as *ad hoc* development and high population growth exerts pressure on social, economic, and environmental wellbeing (Zinia & Kroeze, 2015). This is particularly the case for Dhaka, Bangladesh, one of the world's most densely populated cities. The residents of Dhaka also face climate change (particularly extreme heat, and extreme weather events) and poverty. Green adaptation strategies for maintenance or improvement of ecosystem services can present an effective response but, to date, no formal or coordinated activities have progressed.

In considering ecosystem services and associated green adaptation strategies, urban areas are often categorized as separate ecosystems (see Bolund & Hunhammar, 1999; Grimm & Redman, 2004; McIntyre, Knowl-Yáñez, & Hope, 2000; Niemelä et al., 2010). To evaluate green

adaptation strategies for Dhaka, we define ecosystem services as those ecosystem functions that contribute to human wellbeing (MA, 2005; TEEB, 2010). Common services provided by urban ecosystems include production of fruits, grains and seeds; carbon sequestration; microclimate regulation; noise abatement; air, water and pollutant filtration; pollination; and recreation (e.g., boating, fishing, picnic) (Bolund & Hunhammar, 1999; Escobedo, Kroeger, & Wagner, 2011; Haase, 2015; Zinia & McShane, 2018).

Green infrastructures, ecosystem-based adaptation or eco-infrastructures are well-known urban ecosystem services management strategies (Betancourth, 2011; Cameron et al., 2012; Geneletti & Zardo, 2016). Integration of urban green spaces with other urban infrastructure can be effective adaptive responses to, for example, extreme heat events (Hansen & Pauleit, 2014). Importantly, for developing countries, green adaptation responses present affordable options, utilize ecosystems for multifunctional purposes, and involve multiple stakeholders (Goodess et al., 2013; Hulsman & Van Wesenbeeck, 2011).

Feasibility is one key concern essential to evaluate green adaptation

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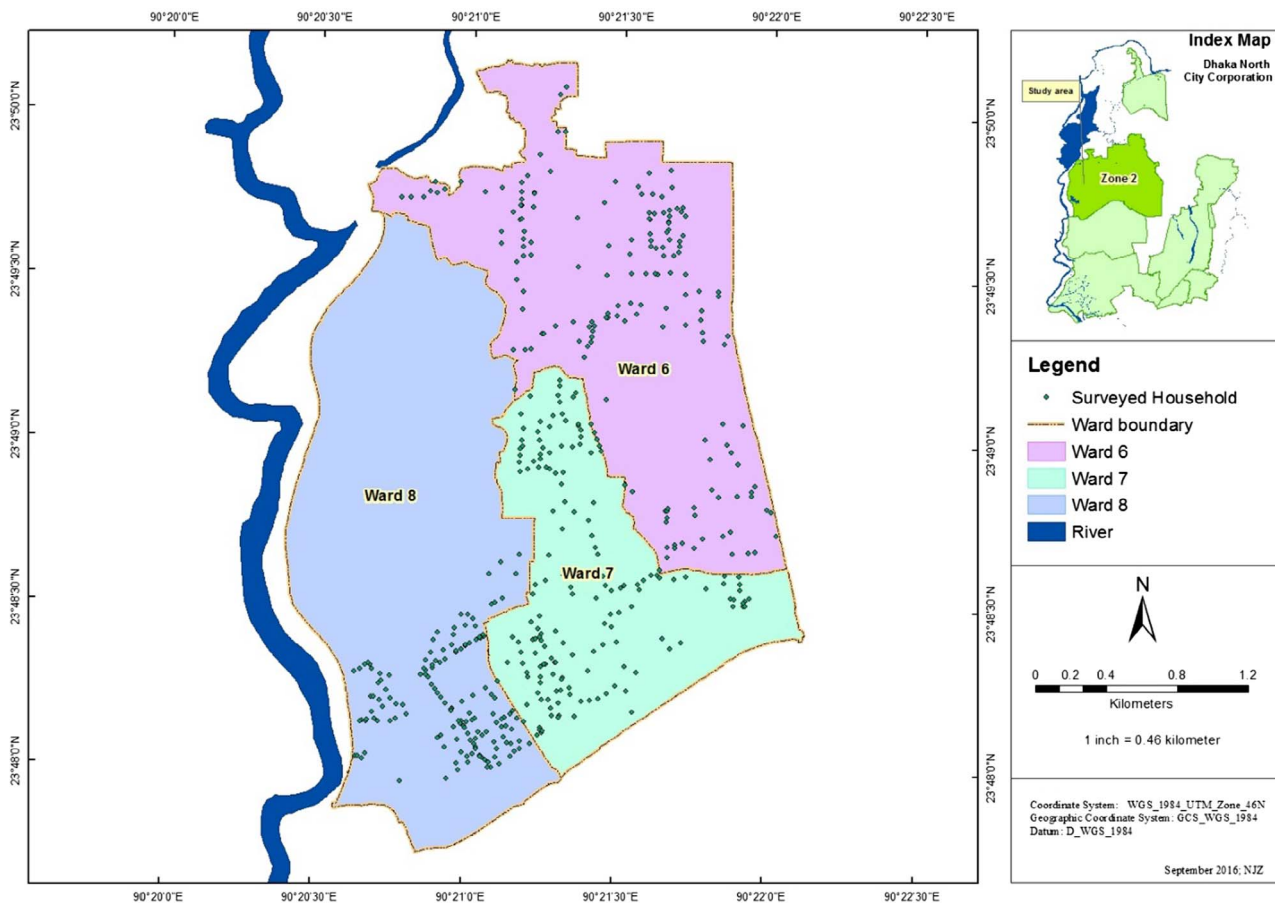


Fig. 1. Location of the study area.

strategies for ecosystem services management. There is a clear distinction between economic and financial feasibility analyses. Economic analysis evaluates a proposed intervention in terms of economic (cost, benefit), social and environmental issues concerning its worthiness for the community and the developer or user. Financial analysis considers the cash flow (income and expenses) associated with the proposed intervention (Halil, Nasir, Hassan, & Shukur, 2016; Liang & van Dijk, 2010). Several studies consider both analyses: Liang and van Dijk (2010) for decentralized waste water reuse systems, Giurco, Bossilkov, Patterson, and Kazaglis (2011) for water treatment and industrial water reuse synergies and Halil et al. (2016) for green building projects. We assess economic feasibility in a qualitative manner focusing on individual and collective affordability, that is, the purchasing power (Jana, Bardhan, Sarkar, & Kumar, 2016) for implementing green adaptation strategies in Dhaka.

Social acceptance is crucial for successful implementation of strategies and projects for current and future planning (Khorsand, Kormos, MacDonald, & Crawford, 2015; Yuan, Zuo, & Huisingh, 2015). We define social acceptance as an individual or a group of local resident's support(s) (high to low) reflected in their preferences for implementability of green adaptation strategies. This follows the findings of related studies (e.g. Chin, Choong, Wan Alwi, & Mohammed, 2014; Wüstenhagen, Wolsink, & Bürer, 2007; Zhao, He, Johnson, & Mou, 2015) including studies particularly focused on green adaptation strategies (see Jung, Moula, Fang, Hamdy, & Lahdelma, 2016; Zhao et al., 2015).

Dhaka is the capital city of Bangladesh located at the confluence of three major rivers, the Ganges, the Brahmaputra and the Meghna. More than 12 million residents occupy a total area of about 1464 km² (BBS, 2013). Its annual population growth rate is 3.5% (BBS, 2012). Urban

expansion is expected to occur in the peri-urban (fringe) areas (Roy, 2009). Typical of Bangladesh more generally, Dhaka is experiencing extensive land use change led by rapid urbanization (Dewan & Yamaguchi, 2009). Mostly, agricultural lands are converted to built-up areas, brick fields are established in the fringe areas, forests are destroyed to meet fuel needs, and illegal encroachment of common resources such as rivers, lakes and wetlands by developers is prevalent and is affecting ecosystem services (Rana, 2011). Growth of informal settlements such as slums is contributing to environmental pollution in Dhaka (Dewan & Corner, 2014). Urbanization, along with urban expansion, poses severe impacts on ecosystems (wetlands, rivers, parks, agriculture land, forest) at multidimensional scales which is a matter of concern (Byomkesh, Nakagoshi, & Dewan, 2012; Zinia & Kroeze, 2015). There is an urgent need to assess the states of these ecosystems and to implement measures to stop further deterioration and to maintain or improve ecosystem services for human wellbeing. Yet, no empirical research has been undertaken thus far on green adaptation strategies for managing ecosystem services in Dhaka.

Thus, we have been motivated to evaluate relevant literature to formulate a list of green adaptation strategies for urban ecosystem services management. From this assessment, we contextualize green adaptation strategies given the extant literature on urban development and related impacts on ecosystem services more generally. We then evaluate social acceptance and economic feasibility of green adaptation strategies for urban development of Dhaka. We focus on green adaptations that are possible to implement individually and/or collectively, are less technology and capital-intensive, and require minimum government support. Our empirical study is novel in that as it integrates social, economic, and environmental aspects of urban development: the first research for Dhaka city.

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