A Comparison of Nature-based Solutions and Related Policies for Urban Environment in China and Canada

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Abstract. *Nature-based solutions (NBS) are considered and implemented in many places around the world as a means to mitigate the impact of climate change on the urban environment. NBS can provide useful approaches to mitigate the urban heat island effect, reduce energy consumption of buildings, sequestrate carbon from the atmosphere, as well as improve comfort to pedestrians in the urban environment. However, the implementation of NBS usually requires extra resources, i.e., valuable land within the urban fabric, additional funds for the design and construction of buildings that incorporate NBS, and additional operational costs for maintaining relevant systems, which may conflict with individual building owner's interests, but nonetheless, be beneficial for the public at large. Under these circumstances, relevant policies should be established to set minimum performance requirements and incentives be introduced to encourage the implementation of relevant practices. China and Canada have set a target of achieving carbon neutral, by 2060 and 2050, respectively. Implementing such policies is critical for realizing the contributions of NBS in the building sector and helping achieve carbon neutrality in urban areas. For the study described in this paper, polices related to the implementation of NBS as issued by selected cities in China and Canada are reviewed. Scopes and limitations of policies from these two countries are summarized and compared. Suggestions and requirements provided in the policies are discussed in conjunction with the findings and conclusions from scientific articles related to the NBS.*

Keywords: *Carbon neutrality; Climate change; Nature-based solution; Policies*

1. Introduction

The increase in greenhouse gas (GHG) concentrations in the atmosphere is the primary cause of climate change, according to the Intergovernmental Panel on Climate Change (IPCC) (Stocker et al., 2013). Countries with significant carbon emissions have formulated strategies and blueprints to curtail or offset their CO_2 emissions in the forthcoming decades, with the goal of attaining a carbon-neutral future. The building sector is responsible for approximately 37% of all direct and indirect CO_2 emissions on a global scale (United Nations Environment Programme, 2022). Consequently, any advancements towards reducing CO_2 emissions in this sector could have a substantial impact on achieving the carbon neutrality. NBS are increasingly recognized as a viable means for mitigating carbon emissions in the construction industry and communities, owing to their capacity to effectively alleviate the urban heat island effect (Bass et al., 2002; Imran et al., 2019; Tiwari et al., 2021), decrease surface temperatures of buildings(Alexandri & Jones, 2008; Cascone et al., 2019), and sequester CO_2 (Gratani et al., 2016; Luo et al., 2015). However, the implementation of the NBS usually requires extra

resources from municipalities or owners of properties such as valuable land of urban area, additional cost for the design and construction of buildings that incorporate NBS, as well as additional operational cost to maintain relevant systems. Given these circumstances, it is important to develop policies that establish minimum performance requirements and provide incentives to encourage the implementation of relevant practices. China and Canada have officially committed to achieving carbon neutrality by 2060 and 2050 (Government of Canada, 2021; IEA, 2021), respectively. The implementation of such policies will be crucial to realizing the potential benefits of NBS for the building sector and aiding attaining carbon neutrality in urban areas. In this study, policies pertaining to the development of NBS for urban areas, such as urban forestry and vegetation, green roofs, and green facades, in these two counties are reviewed and discussed. Furthermore, the discussion is conducted from two perspectives: urban forestry and NBS on buildings given that urban forestry operates on a larger scale and is typically implemented in public areas, whereas NBS on buildings are typically determined by property owners.

2. Urban Forestry and Vegetations

In Canada, policies related to urban forestry and vegetation are mainly issued and managed by municipalities. The direct involvement of the federal or provincial governments in respect to the issue of urban forestry is very limited. Policies for urban forestry and vegetation can be categorized as strategic plans for the management of urban forestry, and by-laws. Typically, strategic plans encompass the following elements: elucidating pertinent concepts; evaluating the existing state and practices; recognizing challenges; outlining future plans and objectives; and offering suggestions on how to accomplish those plans and objectives. The future plans and objectives regarding the development of urban forestry and vegetation are moderately distinct. The strategic objectives outlined in the Toronto Strategic Forest Management Plan (City of Toronto, 2013), released by the City of Toronto, entail several key aspirations. These include a targeted expansion of canopy coverage by 40%, the attainment of equitable distribution, the promotion of biodiversity, heightened public awareness concerning the manifold benefits of trees, the encouragement of stewardship and education to nurture the urban forest's well-being, and the enhancement of monitoring to facilitate effective management of the urban forest. For the City of Vancouver, key actions in its Urban Forest Strategy (City of Vancouver, 2018) include protecting the urban forest during development, planting trees to expand its growth, managing trees for health and safety, engaging citizens in urban forest activities, and monitoring the overall status and condition of the urban forest. The Urban Forest Strategy document also specifies quantitative targets which include increasing the urban forest canopy to 22% by 2050 and doubling street tree density by 2030. Regarding the City of Ottawa, objectives of the strategic plan in its Urban Forest Management Plan 2018-2037 (City of Ottawa, 2017) are to achieve urban forest sustainability, enhance protection and establishment, improve knowledge and management, expand community engagement and stewardship, foster a resilient and diverse urban forest, minimize associated risks, and implement proactive management practices with adequate resources. This plan does not set a specific target for future canopy cover. In respect to municipal by-laws, those governing urban forests have authorized, under certain circumstances, the modification or removal of trees situated in public spaces. Furthermore, these by-laws have established specific minimum requirements for safeguarding urban trees.

Government entities at various levels in China issue policies pertaining to the development and management of urban forestry and vegetation. The national objectives, goals and guidelines for the future development and management of urban landscaping are provided in the National Urban Infrastructure Construction Plan for the 14th Five-Year Plan (Urban Construction Department , 2022) issued by the Urban Construction Department under the Ministry of Housing and Urban-Rural Development of the People's Republic of China. The plan sets out general requirements for development of urban green spaces, including increasing coverage from 38.2% (2020) to 40% by 2025, restoring and rebuilding green areas due to past overdevelopment, enhancing biodiversity and preserving the current green areas. The species of plants mentioned in this plan are not limited to trees but encompass a combination of vegetation that constitutes the landscaping. Subsequently, municipalities issue specific regulations that align with the national plan based on their specific situations. As examples, Chongqing Urban Landscaping and Greening Regulations issued by the Chongqing Municipal Government, require a minimum green area of over 30% for residential projects and over 25% for rebuilt residential projects. Additionally, administration and public service facilities are mandated to have a green area greater than 35%, whereas commercial land should have a minimum of 25% green area, business land at least 10%, and road, street, and transportation land should allocate more than 20% for greenery. These regulations also encompass measures aimed at enhancing the existing urban green areas and actively encourage the use of NBS on buildings. Similarly, in Shanghai, a comparable regulation specifies a minimum green area of 35% for residential projects, 25% for rebuilt residential projects, 35% for public facilities, 20% for industrial areas, 25% for main roads, and 15% for other roads. The regulation for Shanghai also includes requirements for tree sizes (diameter greater than 8cm) and encourage the use of nature-based solutions on buildings. Whereas, in Beijing, the only quantitative requirement imposed is a minimum 30% green area for residential projects. Other than providing quantitative requirements for green spaces, all these municipal regulations also incorporate provisions for green area protection requirements and stipulate particular penalties for non-compliance. Moreover, the regulations stipulate that local governments are obligated to undertake proactive measures aimed at enhancing public awareness regarding the manifold advantages associated with green areas, as well as foster the integration of NBS into building practices.

Both China and Canada have implemented policies with the objective of expanding green areas, fostering biodiversity, and safeguarding existing green spaces. These measures have direct or indirect implications for mitigating carbon emissions in urban environments. Moreover, both countries' policies emphasize the importance of raising public awareness about the numerous benefits offered by green areas. Additionally, there is an emphasis on the need to enhance monitoring efforts, indicating a recognition that current methodologies may not adequately capture the full extent of the benefits derived from NBS.

In Canada, municipalities have the primary authority to manage urban forestry development. In China, municipal regulations align with the objectives, goals, and guidelines provided by the national plan. This gives the Chinese government a better overview of the overall development of urban green spaces. In contrast, the lack of federal authority in Canada makes it difficult to assess the overall conditions of urban green areas nationwide. Furthermore, it should be noted that strategic plans in Canada are not obligatory, which introduces an element of uncertainty regarding the achievement of their stated objectives. In Canada, policies frequently incorporate

future plans as part of their framework, allowing for a more forward-thinking approach to urban development. On the contrary, China's policies often focus on specific time periods, such as 2020-2025, rather than encompassing comprehensive long-term strategies. This approach may inadvertently neglect the importance of formulating overarching plans that extend beyond short-term goals given the nature of municipal development and the complexities involved. Hence, it appears worth considering the potential advantages of adopting longer-term plans. By extending the planning horizon, municipalities can account for evolving needs, anticipate future challenges, and implement more effective and sustainable solutions. As well, longer-term strategies enable a more holistic and proactive approach to urban development, fostering resilience and adaptability in the face of changing circumstances such as that of climate change. Throughout Canada, certain municipal strategic plans have included specific data on the carbon sequestration and carbon storage capacities of urban forestry, along with their corresponding monetary values based on prevailing market rates for carbon offsets or credits. As an example, the City of Toronto has estimated that the carbon storage value of Toronto's urban forest amounts to $25 million (City of Toronto, 2013). On the other hand, Chinese municipal policies do not typically provide this type of information regarding carbon storage values for urban forests.

3. NBS on Buildings

Typically, the realization of NBS on buildings refers to the implementation of green roofs and green facades on individual buildings. Currently, there is no requirement in either Canada or China for the obligatory implementation of NBS on buildings. However, it is worth noting that Chinese municipal regulations have encouraged the adoption of NBS on buildings. In Canada, the City of Toronto stands as an exception, as it has introduced a specific green roof bylaw. This bylaw stipulates that buildings having a gross floor area exceeding 2000 m^2 must have a minimum coverage ratio of 20% for green roofs. The coverage ratio requirement increases proportionally for buildings having larger gross floor areas. Failure to comply with this bylaw would result in the rejection of building permit applications.

There are several possible reasons for the non-obligatory nature of implementing NBS on buildings that can be identified. Firstly, the lack of mandatory requirements can be attributed to the fact that the implementation of NBS on buildings is not yet a widespread practice, and it necessitates careful consideration of the specific conditions of each building. Additionally, the current development of green roofs and green facades still faces certain limitations. For instance, maintaining such systems under diverse climatic conditions poses challenges, and the benefits derived from these applications need to be weighed against the additional resources required for their implementation and upkeep. Moreover, it is important to recognize that most buildings are privately owned properties, and imposing additional requirements for the implementation of NBS may potentially lead to complications concerning the boundaries of legal jurisdiction.

Nevertheless, there are additional standards or codes that promote the adoption of NBS on buildings. In Canada, the sustainable performance of buildings is evaluated using the Leadership in Energy & Environmental Design Building Rating System (LEED) (U.S. Green Building Council (USGBC), 2021), developed by the U.S. Green Building Council (USGBC). Buildings that achieve LEED certification offer numerous advantages, including recognition for their sustainability endeavors, enhanced marketability and value, cost savings through

efficient operations, improved occupant health and well-being, and environmental stewardship. The implementation of NBS, such as green roofs, can contribute to earning additional credits during the evaluation process by potentially contributing to various aspects, including protecting or restoring habitat, maximizing open space, heat island reduction, rainwater management, outdoor water use reduction, optimal energy performance, building life-cycle impact reduction, and more.

Similarly, the Assessment Standard for Green Buildings, issued by the Ministry of Housing and Urban-Rural Development (Ministry of Housing and Urban-Rural Development, 2019), serves a comparable purpose to that of LEED. The implementation of NBS can contribute to meeting specific requirements outlined in this standard, leading to a higher green building rating. Specifically, the implementation of green façades can enhance the thermal performance of the building envelope, reduce cooling loads, and help mitigate the heat island effect. Furthermore, the integration of ecological facilities aids in reducing runoff pollution, promoting biodiversity, increasing the per capita concentration of green space area, improving rainwater management systems. These measures collectively contribute to achieving a higher rating within the assessment standard. Additionally, achieving the minimum coverage ratio of 75% for green roofs can directly contribute 4 credits to the evaluation. In addition to the inherent advantages of energy cost savings and improved living environments associated with green buildings, another immediate benefit of obtaining a green building certificate in China is the eligibility for government incentives granted to building owners upon certification. The extent of the government subsidy increases in proportion to the achievement of a higher rating. As examples, according to the Special Support Measures for Energy Efficiency and Green Building Demonstration Projects in Shanghai (Shanghai Green Building Council, 2016), the government incentives for a three-star (highest level) green building amount to 100 RMB (20 CAD$) per square meter. Likewise, in Chengdu, the government provides a maximum incentive of 1 million RMB (200,000 CAD$) for green buildings.

4. Conclusions and Recommendations

In conclusion, both China and Canada have implemented policies and strategies aimed at expanding green areas, promoting biodiversity, and mitigating carbon emissions in urban environments. Urban forestry and vegetation policies in both countries emphasize the importance of strategic planning, setting goals for canopy coverage, promoting public awareness, and implementing measures to protect and enhance green spaces. Municipalities play a crucial role in managing urban forestry development in both countries, although China benefits from the coordination of national objectives and guidelines. Regarding NBS on buildings, there is currently no mandatory requirement for their implementation in either country. However, there are voluntary standards and codes such as LEED in Canada and the Assessment Standard for Green Buildings in China that promote the adoption of NBS. Green roofs and green facades can contribute to earning additional credits and higher ratings within these certification systems. It is recommended to introduce mandatory requirements for specific building types or sizes, provide financial incentives such as subsidies or tax benefits to encourage the implementation of NBS, increase public awareness through educational campaigns highlighting the benefits of NBS in terms of energy efficiency and environmental sustainability, and foster collaboration and knowledge sharing among stakeholders to drive

innovation and overcome challenges associated with NBS implementation. While the conclusion acknowledges the need for mandatory requirements and financial incentives, it does not delve into the potential challenges or barriers that may hinder the successful implementation of these measures. Factors such as funding limitations, bureaucratic hurdles, or conflicting interests among stakeholders could impact the feasibility of the proposed recommendations.

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