Lecture Notes in Civil Engineering

Lee Yee Loon
Muthulingam Subramaniyan
K. Gunasekaran *Editors*

Advances in Construction Management

Select Proceedings of ACMM 2021

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Preface

We would like to present, with great pleasure, the selected proceedings of ACMM 2021, Advances In Construction Management. This work is published in the book series Lecture Notes in Civil Engineering, and is devoted to the gamut of sustainable construction issues, from theoretical aspects to application-dependent studies and the validation of emerging sustainable construction materials.

This new book work was envisioned and founded to represent the growing needs of sustainable construction of buildings by using novel materials as an emerging and increasingly vital field. Its mission is to become a voice of the civil engineering community, addressing researchers and practitioners presenting new construction materials, findings, and solutions.

This book comprises 49 contributions, connected by a unifying theme: Advances In Construction Management. Specifically, the presented contributory articles can be categorized into the following parts:

- Architecture Management
- Town Planning
- Project Management
- Building Automation
- Analytical Case Study

Many researchers and academicians have contributed to the creation and the success of this book compilation. We are very thankful to everybody who supported the idea of creating a new LNCE contributory book subline—Sustainable Construction Materials. We are certain that this very first issue will be followed by many others, reporting new developments in the civil engineering field. This issue would not have been possible without the great support of the Editorial Board members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the LNCE editorial staff of Springer, in particular Daniel Joseph Glarance and Priya Vyas, who supported us at every stage of the work. It is

our hope that this fine collection of articles will be a valuable resource for Sustainable Construction Materials readers and will stimulate further research.

Chennai, India K. Gunasekaran
July 2021

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About the Editors

Dr. Lee Yee Loon is currently working as a Professor at University Tun Hussein Onn Malaysia (UTHM). Dr. Lee has completed his Ph.D. in Civil Engineering from University Technology Malaysia (2000). His major areas of research interest are Biomass aggregate concrete, Controlled density geopolymer concrete for pontoon, road on soft soil and peat, Pervious concrete, Engineered stone column, Fastening system for IBS, NDT, Structural appraisal and health monitoring and Engineering management beyond critical path. He is also a member of Professional Associations such as FCSM (Past President, Concrete Society of Malaysia, 2008–2010), MACRI (Life member of Malaysia Association of Creativity & Innovation) and MBIC (Board member of Malaysia Biomass Industries Confederation).

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concrete, Coconut shell concrete, High strength concrete, Self-compacting concrete and Steel-concrete-steel double skin elements. He has published more than 46 papers in peer reviewed international journals.

Architecture Management

Planning, Analysis, and Design of Smog-Free Tower with Louvers in Kolkata

Sija Arun, Rukhsar, Utkarsh Anand, and Pathikrit Bhattacharjee

Abstract Pollution in our environment is one of the most primary issues with which everyone have been dealing with. Among all the types of pollution, pollution in air is of utmost importance. It is the leading cause of the rise of different lung diseases and various other diseases in human beings and other problems in plants and vegetation. Formation of smog plays a huge part in causing air pollution. Smog is formed due to many reasons, some of them being natural and others being man made. In order to curb this form of pollution, lot of preventive measures have been taken and introduced. So, the idea of constructing an eco-friendly smog-free tower was taken. A lot of historical places in India have been losing their beauty because of smog, affecting the white marbles, which were used to build it. In order to enhance the economic and tourist activities near to the Victoria Memorial in Kolkata constructing smog tower is an attractive solution.

Keywords Air Quality Index · Air pollution control · Smog · Smog-free tower · Particulate matter

1 Introduction

Smog is a composite mixture of harmful solid particles and gases in air [1]. The harmful particles include emission from automobiles, chemicals released from factories and other suspended particles. Bad air quality is the reason of death of a huge number of people. According to WHO (World Health Organization), 4.2 million

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people lost their lives due to decreasing quality of air worldwide, especially in second and third world countries [2–4]. Smoke forming inside the house from burning of coal, biogas and cigarette is an ongoing cause of all the major lung problems in these countries [5, 6]. Air pollution has been the leading cause of numerous health diseases from cancer to micro-cardial infection affecting over 40% of the population all over the world [7]. Although the working principle of tower is simple but it is expensive, but not as expensive as human life [8]. The need of clean air has led to a stage where in upcoming decade installing average of one tower in one metro city will be necessary [9].

2 Literature Study

2.1 Air Quality Index

The AQI is the index which is used to determine the quality of air on daily basis and is used by government agencies to tell common people the extent of pollutant present in air. The comparison of acceptable value and observed value of pollutant is shown in (Table 1) from the references [10, 11].

To calculate AIQ of the desired location, Eq. (1) is used. AIQ at Victoria Memorial was calculated as 252.

$$AIQ = \left[\frac{(PM_{obs} - PM_{min}) \times (AQI_{max} - AQI_{MIN})}{PM_{max} - PM_{min}}\right] + AQI_{min} \quad (1)$$

where;
PM_{obs} = Observed 24-h average concentration in $\mu g/m^3$.
PM_{max} = Maximum concentration of AQI color category that contains PM_{obs}.
PM_{min} = Minimum concentration of AQI color category that contains PM_{obs}.
AQI_{max} = Maximum AQI value for color category that corresponds to PM_{obs}.

Table 1 Comparison of acceptable value and observed value of pollutants

Pollutants in smog	Acceptable value of pollutant in atmosphere ($\mu g/m^3$)	Observed value of pollutant in atmosphere ($\mu g/m^3$)
Particulate matters (PM) 2.5	40–60	107.6
Particulate matters (PM) 10	60–100	184.5
Carbon mono oxide	204	320
Nitrogen di oxide	4080	176.29
Ground level ozone	100–180	6.33
Sulfur di oxide	50–80	5.28

Source Central Pollution Control Board (CPCB)

Table 2 Classification of air quality index value

Air quality index value	Level of health concern	Health effects
0–50	Good	Little or no risk
50–100	Moderate	Acceptable Quality
100–150	Unhealthy for sensitive groups	General public not likely affected
150–200	Unhealthy	All may experience some effects
200–250	Very unhealthy	All may experience more serious effects
250–300	Hazardous	Emergency condition

Source Central Pollution Control Board (CPCB)

AQI_{min} = Minimum AQI value for color category that corresponds to PM_{obs}.

AQI around Victoria Memorial Hall 1, Queens Way, Kolkata, West Bengal dated on 27th January 2020 is 252 (Poor). By the reference of below Table 2, it is determined that the site has very unhealthy levels of health concerns, and the health effects that may be experienced by all age group of people have more serious effects.

2.2 Working Principle of Smog-Free Tower

In smog-free tower, wet scrubbers are installed inside the tower to clean the air. These scrubbers clean the air by introducing the polluted air stream with a scrubbing liquid (mostly water). Air from the environment is siphoned by the louvered sides of the tower. The air is trapped inside a wet scrubber. Wet Scrubbers are efficient air pollution control devices used for removing particles and gases from industrial exhausts smog. Wet Scrubber removes dust particles by capturing them in liquid droplets, then these pollutants are collected in the scrubbing liquid. The purified air is released from each levels of the smog-free tower through the top of the tower into air. The water used as scrubbing liquid must be treated before reusing or disposing away as it contains harmful pollutants which should be treated or else can cause harmful side effects. Reed treatment bed is used for treating the polluted water. The polluted water is allowed to pass through the bed and clean water is collected in a water tank. This treated water is used again in the scrubbers. Its efficiency depends upon the power supply provided, low energy scrubbers can collect particles larger than 5 micro-meter, while devices with more power supply can collect 1 micro-meter or less-sized particles. They are also known as absorbers, they require a good gas to liquid contact to attain higher removal efficiency.

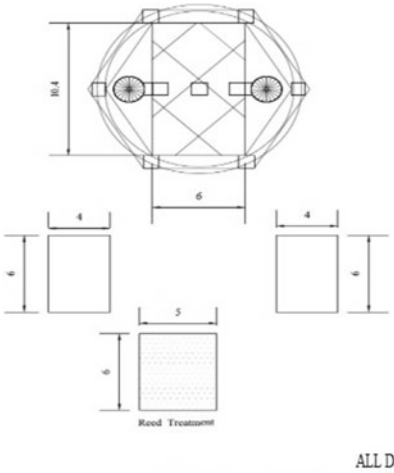

Fig. 1 Plan of smog-free tower RCC underground water tank and reed treatment bed

3 Result and Discussion

3.1 Planning and Dimensioning of Tower and Reed Water Treatment Bed

The detailed plan with dimensions of smog-free tower and reed water treatment bed was prepared using Auto CADD software. The top view, front view and section view of the SFT are prepared. The plan of SFT, RCC UWT and RTB is shown in (Fig. 1), elevation and sectional view of SFT is shown in (Figs. 2 and 3), respectively.

3.2 Analysis

The structural analysis of SFT was done using STAAD Pro software. Various loading conditions were used to analyze the SFT which are acting on it. The analysis result was found to be safe, and the maximum shear force, bending moment and deflection are used to design the beams and columns of SFT manually (Fig. 4 and Tables 3, 4).

Different types of load acting on smog-free tower [10, 11]:

- Dead loads
- Live loads
- Seismic loads
- 1.5 × (Dead load + Live load)
- 1.2 × (Dead load + Live load + Seismic loads along X-direction)
- 1.2 × (Dead load + Live load + Seismic loads along Z-direction)

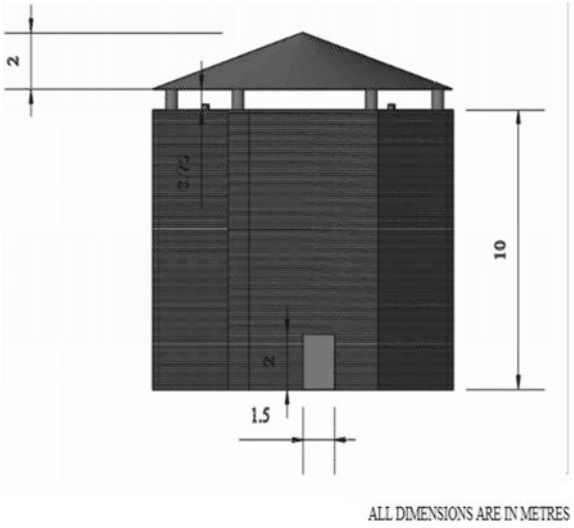

Fig. 2 Elevation of smog-free tower with louvers

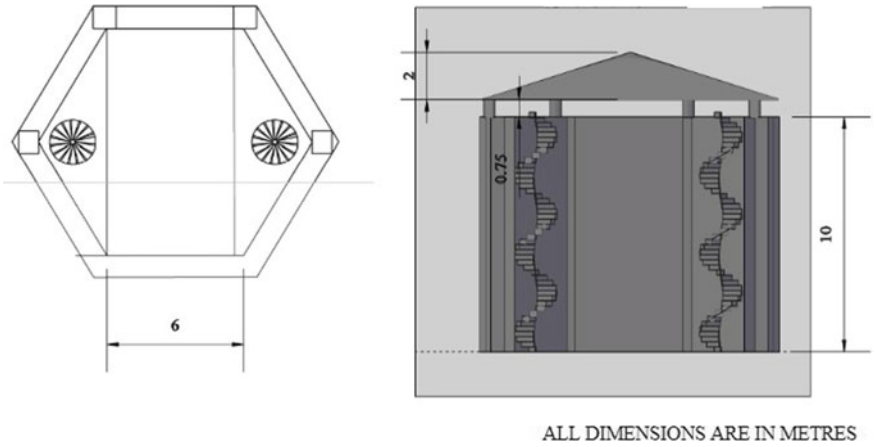

Fig. 3 Sectional view of smog-free tower

3.3 Artificial Reed Treatment Bed

Reed beds are naturally formed habitats found in flooded, waterlogged areas and estuaries. Artificial reed beds are employed to treat polluted water containing pollutants. Reed beds are only used to treat liquids; if they contain any solid pollutants, they need to be first settled in a sedimentation tank and the liquid effluents will discharge to the reed treatment bed and the solids effluents will be treated in sewage treatment plant, or composition of that solid effluent will occur. Reed beds consists of the aquatic

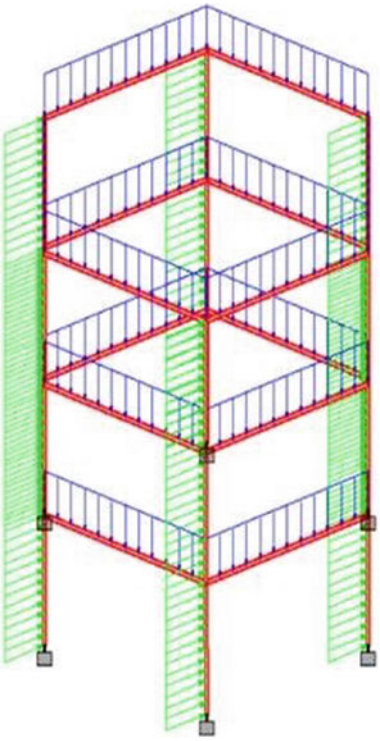

Fig. 4 Various loads acting on Smog-Free Tower

Table 3 Critical Bending Moment Values

Direction of B.M	Maximum positive B.M (kN-m)	Maximum negative B.M (kN-m)	Load Combination
M_y	9.401	9.401	1.5 × (D.L + L.L)
M_Z	36.73	16.78	1.5 × (D.L + L.L)

Table 4 Critical Shear Force Values

Direction of S.F	Maximum positive S.F (kN)	Maximum negative S.F (kN)	Load Combination
F_y	22.78	9.41	1.5 × (D.L + L.L)
F_Z	5.424	5.424	1.5 × (D.L + L.L)

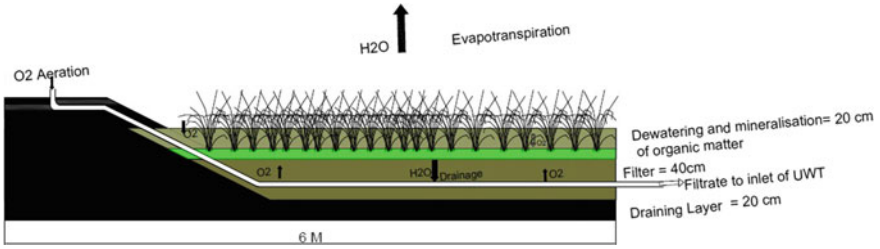

Fig. 5 Artificial reed treatment bed

plants that helps bacteria, fungi and algae to clean the sewage by digesting it in the treatment beds [4]. The diagrammatic representation of artificial reed treatment bed is shown below in (Fig. 5).

3.4 Louvers Selection

- A louver is a blind or shutter window with horizontal slats designed to admit light and air, but to keep away rain and direct sunlight. The angle of the slats can be adjustable or fixed, usually in blinds and windows.
- Modern louvers also consist of steel, metal, wood or glass. Through a metal handle, pulleys or by motorized operators, they can be opened and closed.
- Factors to be considered when choosing louvers: air volume, speed, free area, drop pressure and penetration of water.
- The louver size chosen for use is 3.5 inches or 88.9 mm.
- The type of louvers selected and arranged is shown in (Figs. 6 and 7).

Fig. 6 Louvers

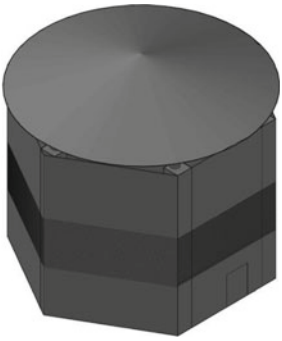

Fig. 7 Louvers in middle section of SFT

3.5 Volume of Air Purified

The tower is divided into three sections; each section consists of two wet scrubbers, and on an average, one wet scrubber can clean 50 m^3/h.

Therefore, volume of air purified $= 3 \times 2 \times 50 = 300$ m^3/h

4 Conclusion

The outdoor Air Pollution is among the top ten health risks in India, with an estimated 695,000 annual premature deaths from respiratory illnesses, compromised immune systems and cardiovascular conditions (IHME). To control this, a smog-free tower is very necessary at the high pollutants emitting zones of the country. Wet scrubbers are used in treatment of smog. Wet scrubbers use water as scrubbing liquid to collect the pollutants and release cleaned air. By constructing a tower of 10 m height and 100 m^2, volume of purified air is 300 m^3/h. It can clean up to 75% of the air [1]. In addition to this, the air purification is also helpful for reducing global warming and acid rain. The power requirement in the tower is low, therefore less energy is wasted. The water used in the tower is reused by treating in reed beds, therefore less wastage of water and no harmful pollutants are released in the surroundings. Tower has low initial cost and low running cost. Some other benefits that are also provided to the government is the attractive tourist spot that will help in strengthening the country's economy. Reed treatment bed will help to reuse water which is used in wet scrubber as scrubbing liquid. All together by reducing pollution, we can achieve a balanced ecosystem and great future.

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Assessing the Role of Nature-Based Solutions in Urban Resilience and Climate Change Adaptation

Kiranmayi Raparthi and Ranee Vedamuthu

Abstract Cities are rapidly urbanizing and face immense social, economic and environmental challenges. These challenges amplify the climate change impacts, thereby posing a serious threat to urban and social resilience. With regard to climate change, ecological researchers globally advocate that nature-based solutions integrate with various ecosystems based approaches, provide biodiversity benefits and address societal challenges. However, the potential of nature-based solutions to build urban resilience and address climate change through urban planning has remained research rhetoric. This research puts forth an effort to assess the ability of nature-based solutions in building urban resilience and addressing climate change. This research incorporates a quantitative research methodology by undertaking a technical and scientific literature review about nature-based solutions, urban resilience and climate change adaptation. Accordingly, the characteristics, dimensions, areas of application, the challenges and opportunities are highlighted. The key research gap between urban resilience and nature-based solutions is identified by developing a socio-spatial framework that focuses on nature-based solutions tradeoffs and its response to urban resilience. This renewed approach highlights that nature-based solutions are cost-effective multifunctional ecosystem services and offer inclusive benefits, ranging from regenerating urban spaces to improving quality of life and reducing pollution. However, this research limits the application of nature-based solutions for urban resilience to local level urban planning and does not focus on master level urban planning. This research emphasizes nature-based solutions as an effective urban policy tool and reinforces its inclusion in local level urban planning for building climate change and urban resilience.

Keywords Nature-based solutions · Cities · Urban resilience · Climate change Adaptation · Policy perspectives

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1 Introduction

Climate change is a multidimensional observable fact and is regarded as one of the greatest challenge human society is facing in the twenty-first century. Cities are rapidly urbanizing and they face immense environmental, social and economic challenges. These challenges are further amplified by the impacts of climate change, thereby posing a serious threat to social and urban resilience [1]. Ecological researchers globally advocate that Nature-based Solutions through the integration of various Ecosystems based Approaches, provide biodiversity benefits and address societal challenges. However, the potential of nature-based solutions in building urban resilience and addressing climate change adaptation through urban planning has remained research rhetoric [2].

This research puts forth an effort to assess the ability of nature-based solutions in building urban resilience and addressing climate change adaptation. Accordingly, the paper first reviews the existing literature on nature-based solutions, urban resilience and climate change adaptation. Later, through the lens of urban resilience and climate change adaptation, the complexity and multifunctional aspects of nature-based solutions is highlighted. Following this, the ability of nature-based solutions in building urban resilience and climate change adaptation is discussed.

Accordingly, the research gap between urban resilience and nature-based solutions is identified by developing a socio-spatial framework that focuses on nature-based solutions tradeoffs and its response to urban resilience. This research emphasizes nature-based solutions as an effective urban policy tool and reinforces its inclusion in local level urban planning for building climate change and urban resilience. This research implies that it is necessary to mainstream nature-based solutions in local level urban planning.

2 Nature-Based Solutions and Urban Resilience

Nature-based solution is an emerging concept that integrates various ecosystem services and management strategies to address the societal challenges related to climate change, food and water security, quality of life and human wellbeing. Ecosystem services refer to the benefits provided by nature to people [3]. According to the Millennium Ecosystem Assessment report 2005, ecosystem services are classified into four categories based on the services they provide to the surroundings. They are, namely, provisioning, regulating, cultural and supporting. Accordingly, nature-based solutions have the ability to improve the quality of life and increase urban resilience through the delivery of ecosystem services [4].

Resilience of urban areas is mainly dependent upon the ability of urban areas to adapt and adjust to the change [5]. Urban resilience embraces the city's ability to respond to the chronic stresses, abrupt socioeconomic change and acute shocks due to natural disasters [6]. Accordingly, urban resilience is not only related to rebuilding

or recovering. It relates to the ability of an urban area to thrive during normalcy and adapt, reorganize and grow in response to a disruption or change [7].

One of the most important aspects of urban policy is urban resilience. It is necessary to increase urban resilience by integrating long-term approaches, mechanisms and disciplines that have an ability to explore feasible transition paths in urban planning and development [8]. Literature regarding implementation of urban resilience highlights the necessity to understand the issues and relationship between new practices and policies related to resilience [9]. Moreover, governance plays a major role and it is necessary to incorporate proactive and anticipatory approaches to mainstream urban resilience in urban planning and development [10].

3 Multifunctional Aspects of Nature-Based Solutions and Climate Change Adaptation

In this section, the benefits and multifunctional aspects of nature-based solutions towards building urban resilience and responding to climate adaptation with regard to the three aspects of climate change vulnerability is highlighted. First aspect relates to exposure and highlights the extent of a community, region or resource exposure to the vulnerability. The second is sensitivity and relates to the degree to which community, region or resource is either responsive or affected to the effect. The third dimension is the adaptive capacity. It highlights the ability of the community, region or resource to either innovate or adjust to the changing conditions.

Within the human settlements context, nature-based solutions by protecting, restoring natural wetlands, there is a possibility of reducing flood risk, soil erosion and ground water recharge, and through constructed wetlands, contribute towards flood reduction and decrease surface flooding.

Urban green spaces, bioretention areas, green infrastructure and permeable areas have the ability to enhance the extent of social interaction, cohesion building and thereby contribute positively to the social, physical wellbeing and quality of life. Moreover, nature-based solutions' adaptive capacity is highlighted by its ability in empowering marginalized groups through efficient management of common pool resources and development of urban green spaces, green roofs and practising home gardening [11].

As such, nature-based solutions either through natural processes or hybrid approaches by integrating natural process with technical-based solutions have the ability to foster climate change adaptation and urban resilience.

4 Nature-Based Solutions Trade Offs

Nature-based solutions literature highlights that nature-based solutions are context-oriented and site-specific. Moreover, due to the multifunctional benefits, tradeoffs exists amongst various aspects in terms of the priorities of each solutions. Tradeoffs with regard to nature-based solutions and urban planning refer to the land use choices that are made to increase or gain from the delivery of one or more nature-based solutions at the expense of losing or diminishing the delivery of the other nature-based solution [12].

This research has categorized nature-based solutions tradeoffs as time-based tradeoffs, spatial tradeoffs, functional tradeoffs, normative ethical (social equity) tradeoffs and species tradeoffs. Time-based tradeoffs highlights that a specific nature-based solution for a specific time has the ability to affect or alter the opportunities in the future. These tradeoffs have both short-term as well as long-term outcomes. For instance, planning for an increase in sea-level through restoration of wetlands has short-term outcome which involves provision of retention space for storm surge flows. On the other hand, alleviating the rate of erosion by increasing the elevation with coastal sediments and growing organic matter is a long-term outcome.

Spatial tradeoffs are related to both scales and cross scales. These tradeoffs occur at various geographical locations and highlight that a nature-based solution for a specific area may cause either a positive or a negative impact in another area. For instance, an urban green space may have a positive impact at one scale by contributing to the inhabitants' quality of life but it may have a contrary effect at another scale by displacing the lower-income households due to the increase in housing costs because of the urban green space [13].

Functional tradeoffs highlight the function of one or many nature-based solution. As such, based on the function, the solution needs to be prioritized. For example, coastal landscapes can function to support recreation and also reduce sea-level rise. Supporting recreation can be carried out through improved walkways and park development but this function may lead to the loss of coastal wetlands and mangroves which may lead to sea-level rise. Normative ethical tradeoffs are associated with the proximity and provision of ecosystem services. Species tradeoffs emphasize that certain solutions support certain types and ignore others [14].

5 Research Gaps and Challenges Governing Nature-Based Solutions

Emerging evidence highlights that nature-based solutions deliver low-cost solutions to most of the climate change impacts through the delivery of ecosystem services. Thereby, provide advantages over grey engineered solutions in building urban resilience. However, it has been identified that there are several knowledge gaps, and limited research has been undertaken till date in addressing nature-based

solutions tradeoffs and its integration in urban planning [15]. This research focuses on the fact that rather than highlighting nature-based solutions as an alternative to the hard-core engineering solutions, it is necessary to identify synergies among different solutions and the possibilities of its integration in urban planning [16].

One main research gap that was identified in the research is the difficulty in identifying indicators for nature-based solutions social–ecological effectiveness. For instance, the effectiveness of nature-based solutions in reducing the flood impact due to increased precipitation is inclined towards various contextual and socioeconomic factors (intensity and frequency of the rainfall, institutional capacity and financial capital to respond to the interventions and the ability to deliver the ecosystem services due to spatial changes) that change over a period of time. As such, the social–ecological effectiveness of NbS varies across various scales and so it is necessary to formulate context-specific strategies at the local level.

The other research gap is the lack of an appropriate framework to estimate the cost-effectiveness of NbS. As a result, the economic benefit of nature is usually underestimated, especially during the long term [17]. This research highlights that due to the multifunctional aspects of NbS, it is often difficult to predict the cost and monetize due to the non-market value of the ecosystem services (such as flood control, water security, urban agriculture and green roofs).

Moreover, nature-based solutions are flexible and also offer long-term solutions with benefits that might not be obtained instantly unlike the grey infrastructure and engineering services. In view of the multifunctional aspects of nature-based solutions, there is a growing consensus among landscape architects, urban planners, engineers and ecologists, that rather than viewing nature-based solutions and engineered solutions in isolation, a synthesis of both the nature-based and engineered solutions may be a viable alternative in many contexts.

6 Socio-Spatial Framework for Addressing the Nature-Based Solutions Tradeoffs

The above sections have described the ability of nature-based solutions to enhance urban resilience and climate change adaptation. This research highlights that lack of a socio-spatial framework addressing the evidence-based practical nature-based solutions tradeoffs might have halted its integration in urban planning. In this regard, it is necessary to bridge the gap between theory (benefits of nature-based solutions) and practise (nature-based solutions tradeoffs) and highlight strategies to deal with nature-based solutions tradeoffs and its response to urban resilience. This research puts forth an effort to synergize urban planning and nature-based solutions. Accordingly, this research proposes a socio-spatial framework that guides the implementation of nature-based solutions, emphasizes nature-based solutions as an effective policy tool and reinforces its inclusion in urban planning for urban resilience and climate change adaptation. Table 1 highlights the Socio-spatial framework for addressing the nature-based solutions tradeoffs.

Table 1 Socio-spatial framework for addressing the nature-based solutions tradeoffs

Tradeoffs	Characteristics of the tradeoffs	Addressing the trade off through urban planning	Examples
Time-based tradeoffs	Short-term actions and long-term actions	Understand the short- and long-term outcomes and how the function, form and scale change over a period of time Conduct stakeholders meeting and evaluate the policies frequently	Planning for sea-level rise through wetlands and mangroves and reefs have various short-term, medium-term and long-term benefits ranging from institutional to community and protection of coastal areas
Spatial tradeoffs	Place-based approaches operational at various scales [18]	Collection of socioeconomic, data and information related to demographics and geological services	Planning for sea-level rise through offshore breakwaters can have adverse impacts in another area
Functional tradeoffs	Prioritization of the outcomes and develop a balance amongst the preferred solutions [19]	Creating overlay land use map, land use land cover map over a period of time	Coastal landscapes can function to support recreation and also reduce sea-level rise
Normative ethical tradeoffs	Providing a utilitarian approach for acknowledging the conflict between the economic efficiency and the social aspect [20]	Conducting potential stakeholder meetings for dialogue on which Nbs provides maximum social equity to the identified issue	Green gentrification, urban renewal and regeneration projects have incorporated green and blue infrastructure and services as elements of upgrading over the general provision of the green and blue services
Species tradeoffs	Providing a utilitarian approach for acknowledging the conflict between the economic efficiency and the ecological aspect of the proposed solution [21]	Understand the type of native that are inherent to the area and collect data regarding the biodiversity and land use land cover	Ecosystem management actions tend to favour certain species and ignore others

Source Developed by the author