2 Regional Trends in Social-Ecological-Technological (SET) Approaches to Sustainable Urban Planning: Focus on Asia

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Abstract

Rapid urbanization coupled with inadequate infrastructure development impacts urban air and water quality amidst other challenges. Sustainable urban planning considers the integration of blue-green infrastructure (BGI) and ecosystems to produce environmental benefits together with improvement in the quality of life. In this context, the social-ecological-technological (SET) framework provides guiding principles for projects visioning sustainable urban futures. Based on the case study analysis and review of integrated SET frames, BGI innovations, and nature-based solutions (NBS) approaches, it is suggested that the policies to improve the urban landscape could consider interlinkages of environmental, economic, and social systems as important at all stages of planning. Drawing on the key observations from the past and ongoing NBS- and BGI-focused projects and programs in selected cities of Asia, this chapter highlights the role of co-designing, technological innovations, participatory implementation and

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evaluation, and up-to-date knowledge as significant to address challenges in operationalizing the sustainable urban planning vision. Furthermore, Sustainable Urban Natural Resources Management framework is proposed as model for integration of air pollution and water quality management with socio-technical options supported by institutions, legislations, and finance to boost ecological sustainability, disaster risk reduction, and climate change adaptation. Overall, the synthesis will help to understand and evaluate the underlined concepts/ frameworks which are essential to transform these approaches beyond project-based interventions into broader urban sustainability paradigms.

Keywords

Urbanization · Blue-green infrastructure (BGI) · Nature-based solutions (NBS) · Social-ecological-technological (SET) · Sustainable Urban Natural Resources Management (SUNRM)

2.1 Introduction

Urbanization is a defining phenomenon and process of this century (Haas 2012). In 2008, for the first time, the global urban population exceeded the non-rural population, and it is estimated, by 2050, 70% of the global population will reside in cities, with >50% of them in Asia (Seto and Shephard 2009). Increasing urbanization impacts water demand, energy demand, infrastructure capacity, pollution trends, and waste management amidst other challenges. It is to be noted that haphazard urban planning could lead to serious negative effects on water availability, air quality, and provision of basic services and can create major setbacks for the urban sustainability agenda (López-Valencia 2019). On a global scale, water crisis, population growth, disasters, climate change, as well as the dynamics of frequency, intensity, and spatial patterns of temperature, precipitation, and other meteorological factors (IPCC 2015) are projected to have severe impacts on urban spaces and population. For instance, future scenarios and projections for the urban regions, particularly in the context of climate change scenarios, show that cities are at high risk of increasing extreme events (Rosenzweig et al. 2011). Therefore, focus on context-specific and location-based solutions remains pertinent for ensuring sustainable urban futures.

Sustainable urban planning will depend on a balanced approach to developing urban infrastructure while fulfilling the green growth targets (Mell 2009; Breuste et al. 2015). Blue-green infrastructure (BGI) is an "interconnected network of designed and natural landscape components, including water bodies and green and open spaces" such as green rooftops, retention and detention ponds, re-naturalized and de-culverted rivers, swales, and "bioswales" or rain gardens (Abbott et al. 2013). BGI is a term that is commonly used to represent a multifaceted approach to ecosystem-based planning where several ecological functions, such as water flow regulation, air and water purification, are considered (Lee et al. 2018). Local climate regulation and adaptation (Lehmann et al. 2014), biodiversity conservation (Watts et al. 2010), carbon storage and sequestration (Mensah et al. 2016), accessibility for amenities, environmental education, and recreation (Wolsink 2016), and other ecological services could be arranged concurrently in the urban planning agenda through BGI. Key dimensions of BGI planning include connectivity, multifunctionality, applicability, integration, diversity, multiscale, governance, and continuity (Renato et al. 2020). Sustainable urban planning could consider integration of the BGI framework and acknowledge the distinctive capabilities of green space and water—and the ecosystems in which they exist—to produce environmental benefits along with improvement in the quality of life (Daniel et al. 2020). Green infrastructure solutions are a key component of an integrated/hybrid approach with a focus on existing natural capital such as wetlands, bioshields, buffer zones, green roofing, street-side swales, porous pavements, wetlands, mangrove ecosystems, etc. It is to be noted that in literature, BGI often tends to comprehend what we define here as green infrastructure.

At length, in the past, governments have implemented hard engineering or gray infrastructure solutions, and currently, there is a growing interest in an integrated approach to tackle contemporary challenges in urban centers. For example, traditional urban drainage techniques have generally focused on the volume of stormwater to be moved, i.e., to move it far away and as quickly as possible from the city. Water quality and the intrinsic significance of watercourses to various forms of life, maintenance of biodiversity, and provision of recreational space to urban inhabitants have long been neglected by policymakers. Gray infrastructure technologies (i.e., hard or engineering approaches) have not been sufficient and effective to manage contamination in the culverted watercourses, and aquifer recharge, and often these approaches do not consider the inherent potential of rivers and streams and related environmental services (Castro Fresno et al. 2005; CIRIA 2015; CIWEN 2007; Dhakal and Chevalier 2016; Burian and Edwards 2002). The volume of stormwater increases when natural hydrologic functions such as interception, evapotranspiration, retention, and infiltration of rainwater are reduced, which raises the peak, rate of flow, and frequency of flooding (Dhakal and Chevalier 2016). Responses to these concerns now indicate a paradigm shift. The novel responses such as BGI seek to replicate the natural mechanisms of absorption and retention as close as possible to the site of origin.

Furthermore, hybrid and green-gray approaches which utilize combined gray and green infrastructures are gaining global consensus to address the shortcomings of traditional gray engineering solutions to tackling urban drainage. For instance, for coastal flood protection, wetlands restoration is combined with engineering measures such as levees. Bioswales, rain gardens, green roofs, street trees installed in sidewalk tree pits, and other engineered ecosystem approaches to climate change adaptation and disaster risk reduction are commonly discussed in literature and development programs (Yaella and Timon 2017).

In this context, the social-ecological-technological (SET) approach broadens the acknowledgment of technological interventions that include focus on ecological functions and has better social appeal and acceptability. In other words, SET perspective aims to address the limitations of a socio-ecological approach that sometimes tends to overlook the role of infrastructure and technology, vital to shaping urban system dynamics (McPhearson et al. 2016). SET also presents as a fitting framework for researchers and practitioners to explore various adaptation options to climate change's impact on urban systems. Adaptation strategies in urban systems are notably hybrid approaches that work across interacting SETs. Hybrid techniques, therefore, combine engineering and ecosystem functions and are located in the SET framework's ecological and technological intersections. For instance, in urban settings, where simply green approaches may be insufficient to tackle the escalating consequences of climate change and other urbanization-related difficulties such as limited space and cost-effectiveness, hybrid approaches are critical. And there is growing evidence that hybrid approaches are cost-effective and offer a platform for integration of multi-objective agendas (Yaella and Timon 2017).

In this chapter, we provide an overview of the SET approaches in the Asia-Pacific context and within the purview of Sustainable Development Goal (SDG) 11: making cities inclusive, safe, resilient, and sustainable. The chapter is presented in two key sections:

- BGI and nature-based solutions (NBS) within the SET context using case studies from the Asia-Pacific region.
- Sustainable Urban Natural Resources Management (SUNRM) framework with a focus on common solutions to air and water quality management.

2.2 Blue-Green Infrastructure and Nature-Based Solutions: Focus on the Asia-Pacific Region

Within the scope of SET systems, the BGI approach is increasingly promoted in the urban landscapes owing to the "multiple benefits narrative in the context of sustainability agenda." Multiple benefits of these approaches have been observed in the urban areas of Australia, Singapore, the Netherlands, the United Kingdom, and elsewhere (Derkzen et al. 2015; Kilbane 2013; Andersson et al. 2014; Yau et al. 2017; Goh et al. 2017; Young 2011). This is because BGI can be integrated into economically efficient solutions for physical challenges like stormwater management and heat mitigation while also improving the social well-being and nature restoration in the urban landscapes (Lovell and Taylor 2013). In most instances, these interventions are typically implemented for a specific purpose such as flood mitigation or to improve local aesthetics (Chin 2015; Vincent et al. 2017). The selected case studies will highlight the BGI and nature-based solutions within the SET context in urban settings of the Asia-Pacific region, i.e., developing, emerging, and developed economies.

2.2.1 Singapore

Singapore, like many other densely populated cities, faces a significant risk of urban flooding. In 2006, Singapore's National Water Agency (PUB) launched the Active, Beautiful, Clean Waters (ABC Waters) Programme to integrate water bodies with nature-based solutions and built infrastructure—turning Singapore into a "City of Gardens and Waterscapes." Furthermore, it is one of the few countries in the world that harvests considerable amount of urban runoff for its water supply, with two-thirds of the state serving as a water supply catchment. Rainwater collection is coordinated through an extensive network of drains, canals, rivers, stormwater collection ponds, and reservoirs before its treatment for drinking water supply (Lim and Lu 2016).

In 2008, ABC Waters Programme initiated the first rain garden in the country which was completed on the 1.5-acre Balam Estate residential complex. The garden spread is 240 m^2 (4% of its catchment area) and drains a highly urban catchment via a system of detention pond layer (100 mm), filtration layer (400 mm), saturated anaerobic zone (400 mm), and drainage layers (150 mm). The water filtered through the system is discharged into a storm drain that flows into the Marina Reservoir, Singapore's first urban supply reservoir. Water quality and hydrological monitoring were conducted after the completion of the project to assess the performance of the rain garden. This rain garden performed effectively in eliminating total suspended solids (TSS) and nitrogen. Overall, an average reduction in total nitrogen (46%), total phosphorous (21%) and TSS (57%) was reported (PUB 2014). The saturated anaerobic layer of this intervention appeared to enhance nitrogen removal by converting soluble nitrogen to nitrogen gas. Results indicate that the system was functioning within its design capability, with some temporal variability in results. The experiment also presented the challenges of managing leaching problems of ammonium and phosphorus, a common occurrence observed for bioretention systems with saturated anaerobic zones. The case study provides an example how a state and resource managers are trying to understand barriers and success rates of an NBS-focused intervention and using that information to improve the efficiency of the system.

In the country, NBS solutions such as bioretention systems and constructed wetlands are used to treat runoff and reduce the peak flow generated from rain falling on impervious surfaces (Benjamin 2012). The city of Singapore is well protected from floods according to an assessment of the Singapore ABC Waters Programme and related projects (World Bank 2012). In another intervention from the country, in 2014, stormwater codes required all new developments and redevelopments of 0.2 hectares or more to implement solutions to slow down stormwater runoff entering the public drainage system by 25–35%. These on-site measures include NBS oriented solutions such as rain gardens, bioswales, and rooftop gardens, as well as detention tanks. Moreover, the long-term land use and transport plan—2011 concept plan—represents strategic planning focused on BGI vision to guide the 40–50-year sustainability planning horizon for the country. Overall, in alignment with the guiding principle of a SET framework, foresight in designing integrated solutions as demonstrated in Singapore paves a way for the region to adopt and adapt some of these practices at various levels. Taking note of that experience, the country is planning collaboration between various land use agencies and the Land Transport Authority to accommodate demand-supply of provisioning services for anticipated population rise and meet the targets of economic growth and environmental revitalization. This plan incorporates proposals from >20 government ministries and agencies into a national development policy document. The concept plan is translated into operational details in the master plan via medium-term land use and transport plans that provide a guideline for development and implementation with solutions that will determine the use of natural resources for the 10–15-year time frame. At the local level, urban design guidelines consider physical integration between transport nodes and surrounding developments. The integrated framework bears the potential to serve as beneficial for managing ecological and development needs and goals (Toan and Van 2020).

The case study demonstrates that carefully planned and implemented investments in NBS and BGI interventions can help shape a more resilient city and a more sustainable society in the long term while also creating more social spaces for communities to meet and interact (Soz et al. 2016).

2.2.2 India

The Asian Cities Climate Change Resilience Network (ACCCRN), Surat, Gujarat, has designed strategies for better management of natural water bodies and prevented construction on the floodplains in the city. Similar practices have been adopted by Burhanpur and Indore in Madhya Pradesh with the support of the Ministry of Environment, Forest and Climate Change (MoEFCC). A key aspect of these interventions focuses on community participation while designing innovative solutions and conserving and managing traditional water management practices. On the otherhand, in Kolkata (West Bengal), wetlands are utilized to clean the city's wastewater. This has not only saved the cost of constructing a wastewater treatment plant but also provided sustenance and livelihood opportunities to 50,000 people through pisciculture and agriculture (Browder et al. 2019).

2.2.3 Sri Lanka

The Sri Lankan capital city of Colombo is situated on a low-lying river estuary and is highly vulnerable to flooding. Like many developing urban zones, Colombo has encountered flooding risk due to a mix of factors acting simultaneously, i.e., rapid economic growth with an imbalance in a change of land use patterns, haphazard land use planning, and reclamation of the city's unique marshlands without a proper environmental assessment. In May 2010, floods paralyzed the city, leaving 36,000 families homeless, marooning traffic, and submerging the country's parliament in 4 ft. of water (Athas 2010). Economic and financial losses were estimated at US$

50 million, although actual losses reached around US$100 million. Rozenberg et al. (2015) reiterated that natural wetlands in this urban landscape had played a key role in flood management while capturing around 40% of floodwaters during storms. However, degradation and loss of wetland systems at a rate of 1.2% (23 hectares/year) has caused several challenges to the city, including but not limited to loss of 1% of its GDP on average per year due to damages from flooding events such as that of 2010 (World Bank 2016).

To address the above mentioned challenges, the Government of Sri Lanka developed a "Wetland Management Strategy" in 2006 in partnership with the World Bank that allocated US$120 million, designed to preserve wetlands, educate the public, and reduce the social and economic impacts of floods in Colombo. In line with the SET context principles, this project uses a mix of green and gray infrastructure with multiple benefits, i.e., reduction of flood risks, improvement of drainage, and creation of recreational opportunities in the catchment area of the Colombo Metropolitan Region water basin. NBS interventions such as wetland protection and restoration were implemented in addition to traditional approaches such as bank protection walls. The investment of >1 million USD in restoring and protecting the 18-hectare region of Beddagana Wetland Park in the center of the city is a part of urban sustainability strategy, primarily toward flood management goals and to boost the value of wetland ecosystem restoration and conservation while promoting ecotourism and ecological space/aesthetics of the city. The income potential of recreational opportunities was estimated at around $13.6 million/year, i.e., >10 times the initial investment. The Park also provides a refuge for flora and fauna and balances the temperature and air quality of the surrounding region (World Bank 2016). This example demonstrates how, in the recent times, the urban landscape management interventions, urban infrastructure investments, planning, and programs are reflective of the emerging paradigms such as BGI and NBS.

2.2.4 China

China's cities face serious challenges related to urban flooding as well as water shortages. During the last several decades, urban sprawl has increased the impervious zone and destroyed/degraded natural resources like forests, lakes, and wetlands, causing a high risk of flooding, stormwater runoff, and pollution. Urban flooding is causing massive loss of property and human lives. Inundation and water shortage challenges prompted the government to design urban water management interventions in 2014 through Sponge City Program (SPC) (Li et al. 2016) with a NBS design and to address the agenda of comprehensive urban water management strategies implementation. 10 cities were selected by the government as SPC's pilot cities in March 2015, and the "sponge city" concept was applied to 30 cities in 2017. By 2020, the government aimed that 20% of the built area of each pilot district characterize a sponge city and 70% of stormwater runoff should be captured, reused, or absorbed by natural surfaces, and by 2030, 80% of each urban center should meet this requirement.

In the year 2008, >100,000 sqm of roofs in the city of Shanghai were vegetated or had green roofs with the coverage doubling the following year and reaching 900,000 sqm in 2010. Noting multitude of benefits (Qian 2009), such as reduction in the runoff, mitigation of the heat island effect, filtration of air, regulation of building temperature, and garden space for urban agriculture, Zhang (2010) analyzed that the typical green roof could reduce annual rooftop runoff by 55%, while another study by Roehr and Yuewei (2010) documented 75% decline in annual rainwater runoff. Therefore, green rooftops are relatively cost-effective when compared to engineered solutions. In Minhang, the cost estimate for the intervention was 125 yuan (US$18.30)/sqm for rooftop lawns and 370 yuan/sqm for a rooftop garden, and an intensive rooftop park costs 125 USD/sqm and an average of 300–400 yuan/sqm for a simple park. It costs only about 1 USD/sqm for the maintenance of these green rooftops Roehr and Yuewei 2010. Further, the "Grain for Green" program or Program of Returning Cultivated Lands into Forest and Grassland was introduced in 2002 to reconvert agricultural fields in steep slopes into forests by providing farmers with cash and grain subsidies.

The set of initiatives documented above point to the fact that the local government agencies and planners in the urban settings are leading efforts to promote interventions that integrate the urban sustainability agenda targets such as green roofs through demonstration projects, promoting incentive structure, and organizing capacity/educational opportunities. Some districts give advice on suitable plants, trees, and flowers and give incentives to encourage private builders to plant green rooftops. Individuals can "adopt" trees on public rooftops by making donations. Moreover, government agencies have designed rooftop demonstrations in public areas to stimulate individuals and citizens to adopt the practice as the city offers around 19 million sqm of roof areas suited for scaling such interventions as per the survey conducted by the Shanghai Landscaping Bureau in 2008 (Soz et al. 2016). However, less attention is given to explain the cost-benefit analysis and precautionary principles that apply in operationalizing BGI and NBS frameworks in short, medium, and long term.

The Natural Forest Protection Program (NFPP) (experimented in 1998) or Natural Forest Conservation Program (NFCP) (launched in 2002) provides both evidence of success in meeting China's goals and illustrates many of the challenges and potential failures of NBS initiatives. In 1998, devastating floods, attributed to overlogging and steep cultivation in the upper Yangtze, Songhua, and Nenjiang Rivers in China (Tianjie 2008), caused a total loss of 166.6 billion yuan (US$ 26 billion). In response, China introduced the NFPP, which called a logging ban to help protect against erosion and rapid runoff. Forest loss in provinces enrolled in the NFCP was >3 times lower compared to non-NFCP provinces (0.62% versus 2.7% forest loss), and program expansion was estimated to grow with annual output from the forest sector by 5.8 billion yuan and increase employment by 0.84 million by 2010. The range of benefits included a reduction in soil erosion and biodiversity loss (Ren et al. 2015). Amid these interventions, the trade-offs associated with NFCP were presented by critics, pointing to the fact that China has become one of the leading timber importers in the world because of the timber restrictions (Tianjie

2008). In essence, the program has exported (teleporting) deforestation to other parts of the world; some of those regions are now losing biodiversity and forest cover at alarming rates. Further, many of the projects undertaken as part of this program involved monoculture plantations of trees that are not native, do not tolerate local conditions, and fail to provide quality habitat for wildlife (Luoma 2012).

2.2.5 Nepal

Rapid and haphazard urbanization in the Kathmandu Valley in this state has witnessed severe wastewater management problems. Studies show that only about 12% of urban households are connected to sewer systems. Wastewater treatment is virtually nonexistent and almost all the wastewater is discharged into nearby rivers without any treatment. In general, wastewater generated by about two million residents in the city has severely deteriorated the water quality of the Bagmati River (WASH 2011; WaterAid 2006). This has primarily affected the poor people who live in the basin and are most exposed to pollution, degraded and contaminated natural resource systems. In the late 1990s, the Environment and Public Health Organization (ENPHO), with the support from WaterAid in Nepal, UN-Habitat (United Nations program for human settlements and sustainable urban development), and ADB (Asian Development Bank), piloted the concept of constructed wetlands as a small-scale decentralized wastewater treatment strategy. The Sunga wetlands, like most constructed wetlands in Nepal, used a reed bed treatment system (RBTS) that constitutes a bed of uniformly graded sand or gravel with plants such as reeds growing on it. Wastewater is evenly distributed on the bed and flows through it either horizontally or vertically. As the wastewater flows through the bed of sand and reeds, it gets treated through natural processes like mechanical filtering, chemical transformations, and biological consumption of pollutants in the wastewater. The process employs simple natural phenomena and native plants (most commonly, *Phragmites karka*) as it is effective, inexpensive, and easy to manage. The 375 m^2 Sunga constructed wetland can treat 50 m^3 of wastewater/day, the approximate amount produced by 200 households (Tuladhar et al. 2008).

Community support was noted as a key to the success of the intervention after referring to the incident, i.e., failed effort to construct a wastewater treatment wetland in the nearby municipality of Siddhikali due to protest by a few community members. In the case of Sunga wetlands, the planning community was approached to discuss plans for building the wastewater treatment wetland; further they were actively involved (provided labor during construction) and formed a committee for construction and maintenance operation as per the general guidelines of the SET approach. The key highlight is the demonstration of a participatory approach to NBS oriented solutions, buy-in by the local communities, reduced cost of construction, and a better guarantee of the long-term sustainability of the intervention. Monitoring data showed that the system is effective in removing pollutants, such as suspended particles, ammonia nitrogen, BOD (biochemical oxygen demand), COD (chemical oxygen demand), and pathogens. The total construction cost of the wetland amounted to approx. US$ 26,000 at around US$ 40 per m^2 with an average annual operation and maintenance cost of about US$ 290 (Water Aid 2008).

This example shows how NBS is applied as location-based integrated solution. As such, restoration of natural wetlands or maintenance of constructed wetlands for pollution mitigation has significant momentum in the wastewater management segment, more recently as an NBS solution (Nagabhatla and Metcalfe 2018). Also, the case of Sunga wetlands restoration set a precedent for scaling in other urban ecological systems in Nepal and other countries in the region with similar socioeconomic and sociocultural settings. The national urban development projects in Nepal, such as the Urban Environment Improvement Project, have integrated this as a case of best practice; however, a major challenge to scaling of this SET approach is the availability of land to promote and expand the use of constructed wetlands.

2.2.6 Fiji

The rivers and coastline of Lami Town in the Republic of the Fiji Islands are prone to flash and surge flooding. A study by Rao et al. (2013) provided a cost-benefit analysis as part of the Climate Change Initiative, UN-Habitat Cities, and UNEP Ecosystem-Based Adaptation Flagship program. It has been envisioned to guide the decision-makers when considering several available options for climate change adaptation. Adaptation responses were categorized into ecosystem-based adaptation options, social/policy options, and gray engineering options.

Life cycle costs including sensitivity analysis were conducted for these four scenarios: (a) ecosystem-based adaptation options, (b) social/policy options, (c) engineering options, and (d) inaction. It was concluded that ecosystem-based adaptation options integrated with engineering options, i.e., BGI provides a greater benefit-to-cost return in terms of avoiding damages and providing ecosystem services such as supporting inshore artisanal fisheries. The most vulnerable areas of Lami being near rivers, coast damages worth nearly US$115 million were estimated. However, the implementation of adaptation options costs approximately US$ 12 million over 20 years. It was recommended that strategic planning and prioritization of adaptation strategies given the benefits from various options and identification of potential co-benefits such as employment generated would benefit wide range of stakeholders and facilitate regular monitoring and evaluation of the adaptation plans.

2.2.7 Thailand

Koh Mueng in Thailand experiences flooding despite a dike that provides primary flood protection of the area. To assess conventional and green infrastructure, a framework consisting of four main components had been proposed: (1) identification and valuation of ecosystem services (flood regulation, education, tourism, recreation, and art/culture) for all possible adaptation options including pre-mitigation scenario; (2) hydrodynamic simulations used to assess the most effective flood mitigation techniques, as well as a cost-benefit analysis to assess their economic viability; (3) flood protection measures selected based on a thorough understanding of ecosystem services as well as stakeholder/community participation; and (4) development of an abstract landscape layout plan. The solution options were evaluated for flood risk reduction effectiveness using assessments of economic and physical vulnerability, flood hazards, and ecosystem services. The cost-benefit analysis evaluated direct and indirect losses through the physical and economic vulnerability of cultural artifacts, infrastructure, tourism industry, and building stock. Results of the study indicated that a holistic perspective of economic assessments and ecosystem services, integrated with active participation from all stakeholders, has the potential to provide more environmentally friendly and socially acceptable flood protection measures in places especially with cultural heritage (Vojinovic et al. 2016).

2.2.8 Philippines

The country is susceptible to typhoon devastation. The growing scientific evidence and the experiences of local communities on the role of natural infrastructure such as mangroves to protect from waves and storm surges have catalyzed the development of a comprehensive National Coastal Greenbelt Action Plan (World Bank 2015)—intending to support the protection of coastal vegetation and mangroves for risk reduction and conservation through the establishment of 100-meter-wide zones of vegetation. The program prioritized the eastern Pacific seaboard of the Philippines where typhoons make landfall.

In December 2020, the *Philippine Information Agency*, an official public information arm of the government, supported the ASEAN Centre for Biodiversity (ACB) and the Philippines' Climate Change Commission discourse on biodiversity and building resilience emphasizing to incorporate NBS as part of the approach in addressing climate change adaptation.

2.3 Sustainable Urban Natural Resources Management (SUNRM)

Many cities around the world, especially in developing countries, are experiencing rapid growth of the urban population with domestic and commercial activities and increasing volume of transport and industrialization. These developments have resulted in severe water and air pollution affecting the environment and human health. In the absence of adequate urban sustainable planning policy and action, this growth could occur at an ascending social and economic cost. The World Health Organization (WHO) and other international agencies have long identified urban air pollution as a critical health problem. Air pollution puts a strain on sustainable urban development, which includes economic growth, human well-being, social inclusion,

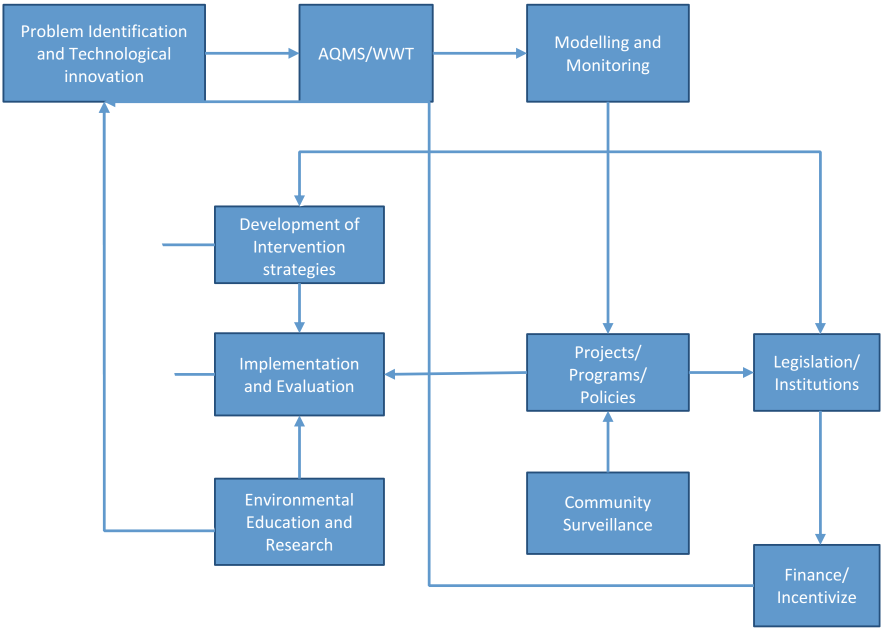

Fig. 2.1 SUNRM (Sustainable Urban Natural Resources Management) framework outline

and the environment. Studies during the past decades have attributed air pollution in megacities in developing countries to emissions from various sources, including industry, vehicular and inadequate inspection, and maintenance programs (Molina et al. 2007; Singh et al. 2007; Wang et al. 2010). A study by Baldasano et al. (2003) provides an account of megacities like Shanghai, New Delhi, Mumbai, Guangzhou, Chongqing, Calcutta, Beijing, and Bangkok which often record ambient particulate matter concentrations violating WHO guidelines. World Bank UFCOP (2016) synthesis reflects that nearly 90% of new urban residents in Africa and Asia reside in underdeveloped, developing, and emerging countries of these regions. The water pollution scenarios are not much different. Water quality is intrinsically linked with human health, poverty reduction, gender equality, food security, livelihoods, and the preservation of ecosystems as well as economic growth and social development (Nagabhatla and Metcalfe 2018). Economic development agendas and environmental sustainability guidelines typically present a challenge of trade-offs in the context of sustainable urban planning.

Urban pollution not only has immediate localized impacts on human health and well-being but also contributes to regional and global air pollution and water cycles due to the "urban heat island" effect. For example, the emission of greenhouse gases (GHGs) resulting from the combustion of fossil fuels in the industrial and transportation sectors contributes to global climate change and are estimated to grow significantly in the cities of developing countries (Johnson et al. 2011).

The Sustainable Urban Natural Resources Management (SUNRM) approach (Fig. 2.1 presents a schematic presentation of the framework) involves a combination of various air and water quality management approaches and tools which could enable planning strategies to improve air and water quality. While air quality management approaches exist in various regions, water quality management strategies are not standardized or lack consistency, although water resources management in general is part of urban planning agendas.

Keypoints of SUNRM Framework

The political will to transform the best available scientific and technological knowledge into action, backed by strong societal support, is the most crucial factor in successful environmental management (Molina et al. 2019). Note that the adoption of comprehensive policies and integrated framework to addressing underlying causes rather than focusing on these challenges in isolation remains key to achieving urban sustainability. In this context, a ten-point agenda is suggested for consideration and implementation by the city/urban authority to successfully tackle pollution challenges and assist their transition to sustainable BGI/NBS paradigms.

1. Problem identification and technological innovations in air/water pollution control aligned to social-ecological-technological approach.
2. Introduction of Air Quality Management System (AQMS) for baseline air quality assessment and management and wastewater treatment (WWT) for water quality management.
3. Introduction of real-time smart air/water quality modeling and monitoring programs—national to community monitoring networks.
4. Identification of gaps and development of intervention strategies such as Environmental Impact Assessment and Water Quality Impact Assessment, promotion of NBS interventions like urban green spaces, terrace garden, etc.
5. Implementation and evaluation of changes as well as impacts.
6. Development and enforcement of projects, programs, and policies for the promotion of NBS/BGI.
7. Legislations and institutions are to be established to regulate commercial activities that do not comply with/subscribe to the norms of air/water pollution management.
8. Provide fiscal incentives and tax exemptions to promote application/scaling of green and clean technologies.
9. Integration of environmental education and SDGs into education curricula and enabling research collaboration across the nations.
10. Establishment of community monitored surveillance system of defaulters and champions.

In the above context, Annexures 1 and 2 outline programs and policies incorporating the focus on innovation and smart interventions as key mechanisms for sustainable urban development, including the agenda highlighted in SDG 11 goals and targets, like Target 11.B calling for a substantial increase in the number of cities and human settlements adopting and implementing integrated policies and plans toward inclusion, resource efficiency, and mitigation of and adaptation to climate change. Also, Target 11.6 aims at reduction of adverse per capita environmental impact on cities, including paying special attention to air quality and municipal and other waste management. The interventions showcased in the Annexure are example of programs that apply integrated framework such as SUNRM. These examples were selected to reflect how small and medium towns and megacities in the Asian region are addressing the set of challenges specific to their context. These interventions do reflect a shift in paradigms toward inclusive and sustainable urban growth and water management solutions. While smaller cities appear to be more specific and tailored to the city's unique needs and available resources, in the large cities, dealing with high levels of water and air pollution issues, energy demands, incorporation of green infrastructure norms and regulations, and environmental sustainability obligations—balancing economic growth and ecological restoration can be a challenging task and makes it difficult to implement the sustainable urban planning. Altogether, the impacts of ongoing set of projects/programs may not reach the desired level, however, these proposed interventions offer potential towards the creation of vision and strategy to combat the challenges and to support the vision of sustainable urban future scenarios that promise social, technical, and ecological equilibrium.

2.4 Discussion Points

Rapid population growth and increasing energy use in sectors like transportation and industry, particularly such activities in the urban region, generate high levels of pollution (air and water). Unsustainable environments are created when population density is combined with insufficient provisioning services and haphazard infrastructure development. Various SET systems are available to mitigate urban matters, and many countries have established contamination and pollution management standards and strategies in recent years, which provide an important planning tool to improve environmental and human well-being goals. In many cities and urban landscapes in the Asian region, operationalization of these SET frameworks through project-based interventions and upscaling is limited.

In Asia, Singapore is a leader in employing these new paradigm approaches to designing sustainable urban development plans such as the ABC Waters Programme. In the last two decades, China has implemented flood management regulations and frameworks that are more comprehensive. The National Flood Management Strategy (2005) emphasizes nonstructural measures as a supplement to structural strategies, complementing the 1997 Flood Control Law. Bangladesh is beginning to explore alternatives to traditional methods. Between 1960 and 2008, Dhaka, one of the world's most flood-prone cities, lost 30% of its water bodies due to urbanization, and the wetlands surrounding the city have reduced from 5.85 km^2 to 3.95 km^2 (GCF 2020). Broad solutions are being investigated by the government, including the Dhaka Water Supply and Sewerage Authority, to address the importance of effective stormwater drainage systems and restoration of water bodies and wetlands.

In an island setting, Fiji's Green Growth Framework (GGF), a tool for accelerating integrated and inclusive sustainable development, to strengthen environmental resilience and manage the anticipated negative effects of climate change to restore the balance in economic growth and development was drafted by the Ministry of Strategic Planning, National Development and Statistics. The guiding principles of the tool focused on the reduction of carbon "footprints" at all levels; efficient utilization of resources and productivity; strengthening environmental stewardship and social responsibility through education; adaptation of comprehensive risk management practices; development of an integrated approach with stakeholder collaboration; and financial incentives for investments in an effective use of resources. GGF presents an approach to support truly sustainable development by identifying ten thematic areas under three pillars—environment, social, and economic. While the environment pillar focuses on building resilience to disasters and climate change, sustainable resources, and waste management, the social pillar emphasizes inclusive social development, water resources and sanitation management, and food security. And the economic pillar aims at energy security, sustainable transportation, green tourism and manufacturing industries, and technology and innovation.

The set of challenges in many countries in the Asia-Pacific region include operationalizing and institutionalizing BGI/NBS agenda in the existing policies and support systems, often due to limited technical and financial capacity (Narayan et al. 2015; Jupiter 2015). While advanced economies have progressed in implementing such solutions, developing countries' interest in the socio-technical approach, BGI, and NBS is expanding (Nagabhatla and Metcalfe 2018). For example, in South Australia, an emphasis on water-sensitive urban design encourages the sustainable use and reuse of water in the urban settings—the intervention is supported by the government as a strategy to combat droughts and a way to cope with water scarcity.

We argue that policies to improve the urban landscape could consider integrated socio-technical management frameworks, BGI innovations, and NBS oriented solutions while pointing to the need to carefully evaluate challenges and opportunities for upscaling. For instance, the case study from China reflects while these urban planning paradigms aim multiple-objective agendas—i.e., mitigating the flood risk, creating urban green spaces, wastewater dilution/treatment plans through constructed wetlands, etc.—the goals and metrics used to evaluate these programs are not framed comprehensively to reflect multiple benefits of the urban planning paradigms. The case studies also point to a common issue with NBS monitoring programs that they tend to assess "easier" evaluation metrics (i.e., hectares reforested), rather than a multitude of direct and indirect suit of impacts or outcomes (i.e., reduction in expected annual damages).

The legislative and regulatory frameworks in many developing countries are emerging to promote the adoption of integrated solutions, as indicated in the water-air pollution section and programs/projects in Annexures 1, 2, and 3. Although the investment in hybrid projects is beginning to rise in the developing countries of Asia and the Pacific, the impact and success of these projects are yet to be perceived, assessed, analyzed, and reported. The World Bank report (2016) enlists that most NBS-based DRM (disaster risk management) interventions are applied in Africa and the Middle East. In 2017–2018, the regions of East Asia and the Pacific, Latin America, and the Caribbean reported a significant growth in the use of NBS for disaster risk management. Additionally, the report elucidates that the investments are still heavily dominated by built infrastructure projects, as clear guidelines on perceptions and implementation of BGI/NBS solutions are limited. Still, the narratives that claim BGI/NBS as cost-effective alternative complementing built infrastructure with co-benefits such as poverty reduction/better employment options/socially inclusive strategy remain strong in theory, and only few of these measures are put in place by urban planners.

Sustainable Asset Valuation (SAVi) developed by IISD (International Institute for Sustainable Development) demonstrates that governments, citizens, and investors can get an attractive return on investment in sustainability-focused assets, programs, and strategies. The ASEAN Catalytic Green Finance Facility for accelerating green finance in Southeast Asia, the Green Climate Fund (GCF), and Green Infrastructure Financing programs by World Bank are a few of many organizations committed to supporting developing countries' climate change mitigation and adaptation commitments and their SDG-related obligations. For example, the GCF report (2020) states that 36% of global GCF ($2.6 billion) is directed to the Asia-Pacific region including 12% ($ 849.9 million) in SIDS (Small Islands Developing States) nations.

The process of securing financing varies significantly across public and private sponsored projects and regions, with significant disparities in funds/financing mechanisms in developing and developed economies. In developing countries, for instance, numerous evolving SET innovations are supported by international donors and multilateral agencies. The emerging and developed economies are taking active measures to commit state financing through a blend of government funding and private sector/equity committed for sustainable urban planning. In that context, insurance policies and products are also evolving to accommodate this agenda. However, such efforts remain mostly noted in developed economies where insurance mechanisms are established and integrated into the existing sectoral operations and guidelines. In the developing states in the region, multilateral institutions such as the World Bank and GCF are providing support by funding initiatives that present a potential to be effective socio-technical systems based on BGI/NBS principles.

2.5 Concluding Notes

To achieve the goal of resilient infrastructure by 2030 as outlined in the SDG agenda, Browder et al. (2019) estimated the need for $90 trillion funding for infrastructure, which underscores the merits of adapting NBS- and BGI-based solutions. To this vision, the central theme of the programs and projects noted in

Annexure 1 reflects on the interconnectedness aspect in BGI, NBS, and the socio-technical approaches. The existing efforts reflect the necessity of regional collaboration along with the cooperation of states and communities for effective implementation of socio-technological oriented solutions created to balance development and sustainability objectives. In addition, the urban regions can design interventions that consider local−/context-specific needs. For example, the Green Bangkok 2030 Project benefits from converting the unused land into green spaces towards a sustainable city vision and addressing integrated goals of air, water, and energy security. However, these solutions are not linear or straightforward in all instances and settings, as many dimensions may apply such as financial commitment, the capacity of the program manager, and acceptability by citizens and communities. Annexure 3 shows emerging collaborations in the Asia-Pacific region—the programs that are aimed to provide support through project funding, sharing knowledge from networking opportunities, and implementation of research. Some programs contain multiple agendas and pledges of participation in a wide range of sustainability (BGI, NBS, SUNRM)-based interventions.

Noting that the urban areas once established cannot be moved, any measure to adopt inclusive development should entwine with the urban ecosystem protection and restoration agenda at the national, regional, and global frameworks. Although investment in BGI and NBS within the socio-technical setups remains essential for sustainable urban infrastructure, a lot of countries are pressed with challenges such as lack of human capacity, financial resources, or understanding of short-, medium-, and long-term trade-offs. As Luoma (2012) explains about the NFPP in China, the trade-off of NBS implementation, the State Forestry Administration has begun collaborating on projects aimed specifically at restoring native species and is working with the Climate, Community & Biodiversity Alliance (CCBA), whose members include Conservation International, The Nature Conservancy, and the Rainforest Alliance (the emerging challenge of teleporting needs attention).

It is evident from the case studies in this chapter that the hybrid engineering solutions have intensely focused on stormwater management to handle urban flooding with few studies on coastal flooding and erosion protection, construction of wetlands, and mangrove-dike solutions for flood management. The SET framework provides guiding principles for projects visioning sustainable urban futures. As we see in the case of Nepal where community intervention resulted in the closure of a project of importance, emphasis on local settings, social and ecological goals, and technological innovation are to be balanced carefully for desired outcomes. Most of the existing solutions in developing countries are focused on a narrow scale and are in the process to configure multi-benefits through boosting infrastructure resilience. This progress will broaden the scope of the NBS/BGI approach in multiple areas with proven evidence that it empowers communities, enhancing project sustainability with cost-effective multiple benefits (economic and non-economic).

Long-term funding is another key challenge in developing countries that are highly dependent on bilateral or multilateral funding for such projects. Besides, the lack of technical guidance for BGI/NBS implementation is one of the most cited barriers in all regions and refers to the understanding and knowledge to assess the performance of such interventions by the policymakers, regulators, and/or permitting agencies, who often prioritize gray infrastructure over such options because of familiarity, existing guidelines on compliance, and permissions. A multilevel incentive structure can serve as a driver for inclusive participation and successful implementation of the outlined agendas. Additionally, forward-looking strategies such as the Sustainable Urban Natural Resources Management (SUNRM) approach derived from the SET framework could be promoted and supported under ecological sustainability, disaster risk reduction, and climate change adaptation measures. For these urban planning paradigms to be adopted widely, incentives need to be created for local stakeholders through public and private financing options, technical support, and policy instrument.

In closing, note that SET innovations and integrated agenda bear potential to balance urban growth, smart employment, ecological sustainability, and more while contributing to the interlinked plan of SDGs, i.e., to SDG 8, decent work and economic growth, and SDG 11—sustainable cities and communities. However, a barrier such as knowledge and capacity gaps, lack of governance structures for managing these multifunctional systems, and balancing trade-offs while delivering multiple goals largely determines the feasibility and endorsement of these planning paradigms. In the long term, success and acceptance of SUNRM framework depends both on the efficiency of technological interventions as well as mechanisms for community involvement and social inclusion. In addition, like for any other development-focused intervention, public acceptance, financial commitment, and policy support remain pertinent to sustain these urban planning pathways. The challenge associated with maintenance, monitoring and evaluation, and upscaling is also crucial towards certifying the sustainability of NBS and green infrastructure approaches in the urban planning context.

With better and more sustainable infrastructure, these integrated solutions can serve useful to managing inequality and social injustice linked to challenges outlined in SDG 6 (water availability and accessibility to all), mainly for the urban poor. It is to be noted that the technological and the social component of the SET framework are aligned with SDG 1 (that includes urban poverty), SDG 2 (managing hunger), water and clean air, and reducing the impacts of climate change. Alignment of SET framework to achieving SDG 7 (affordable and clean energy) and SDG 3 (good health and well-being) is also apparent, as is SDG 5 (gender-focused) agenda. The technological aspect of the SET framework calls for reduced emissions, projecting nature-based solutions bearing potential as a carbon sink, besides as a mechanism to boost climate resilience tying to SDG 13 (climate action), SDG 14 (coastal and marine environmental protection), and SDG 15 (better land management) directly or indirectly.

Conflict of Interest Statement The authors report no conflict of interest for this publication.

Annexure 1

Institutional and policy support systems in selected cities and mega urban centers in Asia that align with the scope of Sustainable Development Goals, particularly SDG 11

City(mega, emerging, or developing city)	Policy/ programLaunch year	Summary and notesReference
Singapore Megacity	Singapore's Voluntary National Review Report 2018	Some of the strategies to achieve SDG 11 are transit-oriented development and planning, promoting public transport, walking, cycling plans, inclusive transport, safer streets, green buildings and spaces, and international collaborations https://sustainabledevelopment.un.org/content/documents/19439Singapores_Voluntary_National_Review_Report_v2.pdf
	Urban Redevelopment Authority (URA) 2011 and 2019	2011 concept plan—Long-term strategic land use and smart transportation (in next 40–50 years) Singapore has a limited land capacity to establish a long-term land use plan that balances land use needs, such as housing, industry, commerce, parks, transport, defense, community facilities https://www.ura.gov.sg/Corporate/Planning/Concept-Plan/About-Concept-Plan
		2019: The master plan is a short-term strategic land use plan (for the next 10–15 years) Proposes zoning strategy to show the permissible land use developments Plan to be reviewed every 5 years and translates the plan's ideas to guide land development https://www.ura.gov.sg/-/media/Corporate/Planning/Master-Plan/MP19writtenstatement.pdf?la=en https://www.ura.gov.sg/Corporate/Planning/Master-Plan
Hong Kong Megacity	Future Hong Kong 2020	To meet SDG 11, Hong Kong has created Future Hong Kong 2030 to promote sustainable development. Numerous strategies developed to drive sustainability. Some of

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City(mega, emerging, or developing city)	Policy/ programLaunch year	Summary and notesReference
		which are: Implementing wastepaper collection and recycling services to help stabilize the price and quantity of local waste management Adopting *electric vehicles*, introducing a smart power grid, and artificial intelligence-driven technology can optimize energy consumption Cleaner production partnership program to encourage local-owned factories to adopt cleaner technologies Set up an HKD 200 million green tech fund to support the R&D and application of decarbonization and green technologies https://assets.kpmg/content/dam/kpmg/cn/pdf/en/2020/04/future-hong-kong-2030.pdf
Tokyo, Japan Megacity	Tokyo's Environmental Plan 2020	Tokyo's strategy toward building a more sustainable society and honoring their commitment to the Paris commitment. And for sustainable buildings, the Tokyo cap-and-trade program, carbon reduction reporting program, and green building program. Aim is to promote energy-efficient homes and expand renewable energy resources to reduce GHG emissions https://www.kankyo.metro.tokyo.lg.jp/en/about_us/videos_documents/documents_1.files/creating_a_sustainable_city_2020_eng.pdf
Shimokawa Town (Hokkaido) *Town referred to as a model for sustainable development Advanced Urban Center in a Developed Nation	Shimokawa Town The Sustainable Development Goals Report 2018	Report promotes comprehensive development strategies such as the Ichi-no-hashi BioVillage, which addresses economic, social, and environmental issues They created an on-demand local *public transportation system* for more efficient traveling To prevent elders from getting isolated/lost, they developed a senior watch system The town is taking measures to

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City(mega, emerging, or developing city)	Policy/ programLaunch year	Summary and notesReference
		preserve water resources, make its forest more resilient to disasters, and establish headwater forests guidelines https://www.iges.or.jp/en/publication_documents/pub/policyreport/en/6571/Shimokawa_SDGsReport_EN_0713.pdf
Toyama, Japan Urban Center in a developed nation	Toyama City The Sustainable Development Goals Report 2018	Has seven plans developed that address SDG 11: (1) Second Comprehensive Plan 2017–2026, (2) Basic Environment Plan 2017–2026, (3) Environmental Model City Action Plan, (4) Land Tolerance Regional Plan, (5) Environment FutureCity Plan, (6) Comprehensive Strategy for City, People and Work (2015–2019), and (7) Resilience Strategy (30-Year Plan) By 2025, approximately 30% of the entire population of Toyama City will be senior citizens. Therefore, the city wants to revitalize public transport, promoting health and an overall better state of well-being *City will make efforts to reduce the heavy reliance on cars*, create a walkable city, and recover the number of public transport users that have declined in recent years https://www.local2030.org/library/478/Toyama-City-the-Sustainable-Development-Goals-Report-Compact-City-Planning-based-on-Polycentric-Transport-Networks.pdf
Kitakyushu, Japan Emerging Urban Center in a developed nation	Kitakyushu City The Sustainable Development Goals Report 2018	Kitakyushu has developed 17 specific actions to achieve the SDGs. To meet the SDG goals, some of Kitakyushu efforts include: Building motivation in life for the elderly; promoting education for sustainable development (ESD) activities; increasing urban resilience by supporting the development of a voluntary disaster-prevention system. Developing an intensive-type

(continued)

City(mega, emerging, or developing city)	Policy/ programLaunch year	Summary and notesReference
		urban structure promotes people- and environmentally friendly *transport strategies*. Promoting public facility management Developing products that can spread worldwide, such as soap-based firefighting foam https://www.uncclearn.org/wp-content/uploads/library/kitakyushu_sdgsreport_en_0713.pdf
Bangkok Megacity	Bangkok Declaration for 2020 Sustainable Transport Goals for 2010–2020 2020	Bangkok's main priority outlined in the policy is to *improve transportation* and technologies in the city. Goals include improving public transport; reducing the use of private motorized vehicles through transportation demand management; and achieving more sustainable intercity passenger and goods transport (i.e., high-quality long-distance bus, inland water transport, high-speed rail over car and air passenger travel, and priority for train and barrage freight over truck and air freight by building supporting infrastructure such as dry inland ports) https://sdgs.un.org/sites/default/files/documents/bangkok_declaration.pdf
Shanghai Megacity	Promoting health in the SDGs 2016	One way in which Shanghai intends on implementing SDG 11 is by enforcing a smoke-free law and promoting and providing universal access to safe, inclusive, and accessible green and public spaces https://www.who.int/publications/i/item/WHO-NMH-PND-17.5
Guangzhou Megacity	UN SDGs Guangzhou Voluntary Local Review 2020	Guangzhou has many goals outlined to achieve SDG 11. Some of these include: Preserving the urban green ecological spaces Refining the quality and the design of the city and highlight its personality promote collaboration Participating and sharing common interests in the community Building sustainable communities

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City(mega, emerging, or developing city)	Policy/ programLaunch year	Summary and notesReference
		Increasing efforts to build public transportation facilities and optimize the traffic Developing innovations in green technologies and promoting the application of green energy https://sdgs.un.org/sites/default/files/2021-01/VLR%20Guangzhou%2C%20China-compressed.pdf
Surabaya, Malaysia Emerging Urban Center	SDG Summit 2019	Different initiatives taken by Surabaya to achieve the SDGs Prioritized disaster risk management against extreme weather They have implemented alternative energy sources such as using waste for fuel to create energy Public and social facilities are provided for free (this includes 49 broadband learning centers, 475 public parks, 524 sports fields, learning center, and community hall) https://sustainabledevelopment.un.org/content/documents/25068Leaders_Dialogue_4_Localizing_the_SDGs_Mayor_Tri_Rismaharini.pdf
Muangklang, Thailand Emerging urban center	Could not find specific policies but it is a famous green city NA	Muangkland, Thailand, is one of the three model towns in Thailand's low Carbon City program Small town with limited resources but has managed to become famous for its green-city development with its many green activities The town created a simple outdoor conveyor belt to separate waste, reuse, and recycle, significantly reducing waste in the municipal landfill. The operation is compensated for by selling compost, recyclable materials from the landfill, and locally grown organic vegetables The city also converted unused land to promote urban farming of vegetables and rice—This project aimed to reduce food miles and energy from food transportation https://wwf.panda.org/?229194/Muangklang-low-carbon-city

Annexure 2

Selected projects and programs in urban landscapes in Asia aligning with agenda outlined in the Sustainable Development Goals, in particular SDG focused on urban development

City/region/agency (mega, emerging, or developing city)	Project/programYear	Summary and notesReference
Programs/projects and case studies		
Yokohama, Japan (Megacity)	Yokohama Partnership of Resources and Technologies (Y-PORT) Project 2015	The city of Yokohama was faced with various urban issues because of the high concentration of the population due to significant economic growth and urbanization To overcome these challenges, such as delayed infrastructure development and pollution from the rapidly increasing population, Yokohama developed a sustainable and environmentally friendly city Now, Yokohama uses its experience in urban development and technologies to help other emerging cities https://yport.city.yokohama.lg.jp/en/y-port-project
ASEAN Southeast Asia	ASEAN SDGs Frontrunner Cities Programme (SDGs-FC) 2018	An initiative under the AWGESC funded by the Japan-ASEAN integration fund (JAIF) This program aims to raise the capacity and profile of 27 ASEAN cities and develop and improve practices/policies toward clean and green sustainable development https://sustainabledevelopment.un.org/partnership/?p=29570 http://urbansdgplatform.org/pdf/IGES%20Policy%20Brief%20-%20ASEAN%20Cities%20Early%20Reactions%20to%20SDGs%20Final%207May2018_FINAL.pdf
	ASEAN Working Group on Environmentally Sustainable Cities (AWGESC) 2009	Improve regional involvement to address the effects of climate change on socioeconomic development in ASEAN Address regional priorities, concerns, and interests Has seven strategic priorities in the plan: (1) nature conservation and

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City/region/agency (mega, emerging, or developing city)	Project/programYear	Summary and notesReference
		biodiversity, (2) coastal and marine environment, (3) water resources management, (4) environmentally sustainable cities, (5) climate change, (6) chemicals and waste, (7) environmental education and sustainable consumption and production https://environment.asean.org/about-asean-cooperation-on-environment/ https://www.doe.gov.my/portalv1/en/info-umum/info-hubungan-antarabangsa/asean-working-group-awg-2/324045#:~:text=The%20ASEAN%20Working%20Group%20on,a%20clean%20and%20green%20environment
USAID (International Cooperation Agency of the United States) Mekong region	Pact and the Mekong Partnership for the Environment (MPE) 2013	There is accelerated growth in the Mekong region which led to the development of this pact. MPE reinforces the responsible development of counties in the lower Mekong region through the constructive engagement of different stakeholders such as governments, businesses, and civil society Promotes responsible investment and encourages public participation through good environmental impact assessment (EIA) policy and practice MPE supports strategies that facilitate socially and environmentally responsible development decision-making https://www.pactworld.org/mekong-partnership-environment#:~:text=In%202013%2C%20USAID%20awarded%20Pact,the%20Lower%20Mekong%20sub%2Dregion
Malaysia	Malaysia Sustainable Cities Program 2013–2018	The goal of the program is to study the sustainable city development efforts in Malaysia Scholars from around the world researched Malaysia Transform findings into instructional materials to enhance and spread sustainable city development lessons across universities in the global south

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City/region/agency (mega, emerging, or developing city)	Project/programYear	Summary and notesReference
		Graduate students and faculty at MIT and UTM studied, reviewed, and refined the research direction MSCP encouraged additional reports, theses, and studies to be conducted in Malaysia https://scienceimpact.mit.edu/malaysia-sustainable-cities-program
Shimokawa Town (Hokkaido Emerging Urban center in Japan)	Ichi-no-hashi BioVillage 2018	Town with a high aging population that experienced hardships living in a colder climate (e.g., removing heavy snow) Shimokawa implemented a new housing community with a woody-biomass district heat supply system to improve elders' quality of life Their energy cost decreased because of well-insulated homes and biomass fuel Also, they created 30 jobs and US$ 0.7 million worth of mushroom production https://www.town.shimokawa.hokkaido.jp/section/2018/05/sustainable-forest-future-community-ichinohashi-bio-village-of-shimokawa-town.html
Toyama (Developing Urban Region of Japan)	Toyama City Low Carbon Farming Village Model 2018	Agricultural land use has decreased as farmers become dependent on non-farming income Toyama is implementing the Toyama City low-carbon farming model to revitalize the abandoned farmlands using renewable resources and providing farmers with other crops than rice, such as vegetables that have a low crop acreage The facility uses renewable power sources to power agricultural machinery and air-conditions greenhouses for crops The produce is shared among the community https://www.local2030.org/library/478/Toyama-City-the-Sustainable-Development-Goals-Report-Compact-City-Planning-based-on-Polycentric-Transport-Networks.pdf

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City/region/agency (mega, emerging, or developing city)	Project/programYear	Summary and notesReference
Kitakyushu (Emerging)	City Forest Project 2018	Launched a city forest project to create urban development that coexists between cities and the natural environment Kitakyushu leases idle company-owned land, unused city-owned land, and sections of parks to local groups that use community involvement to develop green areas These activities may provide new life to idle and unused land, which have become problematic in local areas otherwise https://www.uncclearn.org/wp-content/uploads/library/kitakyushu_sdgsreport_en_0713.pdf
Kuala Lumpur (Emerging)	Urban Mass rapid Transit System—MRT 2016	The advanced and newly established transportation system will provide an efficient and environmentally friendly transportation network in Kuala Lumpur Its purpose is to enhance access and mobility to and from the city center for its 400,000 daily commuters https://aseanup.com/kuala-lumpur-sustainable-development-initiatives/
	River of Life Project 2012	The river cuts through the city and influences the livability and atmosphere of Kuala Lumpur The project will have three phases: (1) clean the river, (2) install gross contaminant traps, and (3) build two wastewater treatments https://www.mymrt.com.my/public/mrt-need-to-know/
Bangkok (Megacity)	The Green Bangkok 2030 Project 2019	The environment department, Bangkok metropolitan administration (BMA) goal is to take advantage of the unused spaces scattered throughout Bangkok (that belong to the government and private agencies) to create more green spaces. https://www.c40.org/case_studies/the-green-bangkok-2030-project
Manila (Developing)	Escuela Taller de Filipinas Foundation, Inc. 2019	Nonprofit organization located in Intramuros, Manila, that implements skills development and training targeted toward indigent youth Students learn about the protection,

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City/region/agency (mega, emerging, or developing city)	Project/programYear	Summary and notesReference
		conservation, and restoration of cultural heritage sites The organization highlights the importance of education and training programs to address challenges in other SDGs and sectors, such as heritage and culture conservation (under SDG 11) https://sustainabledevelopment.un.org/content/documents/23366Voluntary_National_Review_2019_Philippines.pdf

Annexure 3

Regional initiatives, alliances, and coalitions to promote BGI/NBS and integrated natural resource management initiatives in the Asian region

Program	Description	Main agendaReference/source
Asia Smart City Alliance	A platform for different stakeholders (i.e., cities, governments, private companies, international institutions, and academics active in smart city development) in Asia to share knowledge and facilitate discussions	Organizes annual Asia Smart City Conference (ASCC) https://yport.city.yokohama.lg.jp/en/city-promotion/asia-smart-city-alliance-asca
Association of Southeast Asian Nations (ASEAN)	Founded by Indonesia, Malaysia, Philippines, Singapore, and Thailand (10 members) The objectives include: • To accelerate economic growth, social progress, and cultural development • Promote regional peace and stability, respect for justice and the rule of law • Increase collaboration across various economic, social, cultural, technical, scientific, and administrative spheres	The goal is to maintain close and beneficial cooperation between countries using existing international and regional organizations with similar aims and purposes (7 aims found in the ASEAN declaration) https://asean.org/asean/about-asean/ https://asean.org/storage/2020/10/ASEAN-SDG-Indicator-Baseline-Report-2020.pdf
ASEAN ESC Model Cities Programme	Created to encourage the development of environmentally sustainable cities by conducting activities at the local, national,	Model cities receive several benefits, including funding, training, and regional networking opportunities

(continued)

Program	Description	Main agendaReference/source
	and regional levels Supports national focal points by: • Mainstreaming the SDGs; boosting incentives for cities to better fulfill the ASEAN clean land, clean air and clean water indicators • Strengthening or creation of national model cities networks	The last report issued from the program discusses its achievements from 3 years (last report from 2017) of existence Model cities continue to make improvements to local environmental quality by scaling up a variety of innovations https://www.iges.or.jp/en/pub/asean-esc-model-cities-year-3-201617/en#:~:text=The%20ASEAN%20ESC%20Model%20Cities,local%2C%20national%20and%20regional%20levels
Economic and social Commission for Asia and the Pacific (ESCAP)	Largest regional intergovernmental platform with 53 member states and 9 associate members	Goal is to develop inclusive, sustainable, economic, and social development in the Asia-Pacific region Priority is aligned with the implementation of the 2030 Agenda for Sustainable Development and the achievement of the Sustainable Development Goals https://www.unescap.org/resources/sdg11-goal-profile https://www.unescap.org/our-work
Institute for Global Environmental Strategies (IGES)	Strategy aims to achieve a new paradigm for civilizations through conducting innovative policy development and research for environmental measures, incorporating the research into political decisions for sustainable development in the Asia-Pacific region and globally Recognizes sustainable development in the Asia-Pacific region is critical for international growth	Undertakes different programs and projects. Main coordinating body for APAN Collaborates with USAID In charge of hosting ISAP (International Forum for Sustainable Asia and the Pacific 2018) Research and implementation of Japan's Joint Crediting MECHANISM (JCM) https://archive.iges.or.jp/en/bangkok/index.html https://www.iges.or.jp/en/about
Asia Pacific Adaptation Network (APAN)	APAN aims to equip Asia and the Pacific Region with the knowledge for designing and implementing climate change adaptation measures Operations are carried out by subregional nodes: Central Asia, Northeastern Asia, Pacific, South Asia, and Southeast Asia	Publishes the Asia-Pacific Climate Change Adaptation Forum (Seventh APAN Forum) The conference was held recently in March 2021 http://www.asiapacificadapt.net/about-apan/

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Program	Description	Main agendaReference/source
USAID Adapt Asia-Pacific	Assists vulnerable countries to receive financing to address climate change impacts Links climate funding organizations with eligible Asia-Pacific countries to help prepare projects that increase resilience to climate change's negative impact	USAID and the US Department of State-funded "Climate Change Adaptation Project Preparation Facility for Asia and the Pacific Activity" (Adapt Asia-Pacific) specifically 13 countries in Asia and 14 Pacific Small Island Developing States The project improved the government's climate change adaptation strategies and provided technical assistance to allow organizations to access and receive climate funding for projects that increased resilience to climate change Adapt Asia-Pacific was granted over $576 M in financing for climate change adaptation projects, which benefited almost one million people https://www.weadapt.org/organisation/usaid-adapt-asia-pacific https://www8.climatelinks.byf1.io/sites/default/files/asset/document/2017_USAID_ADAPT%20Asia-Pacific%20Final%20Report.pdf https://www.climatelinks.org/projects/adapt-asia-pacific

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