
# HANDBOOK ON BLUE-GREEN INFRASTRUCTURE FOR BIODIVERSITY

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# WHERE ARE WE NOW?

The global pandemic has upended the status quo by which the world operates and has brought forth long-standing issues on urban design at the forefront, and with this, the need for livable urban spaces at a time when it is most needed. As the world prepares for a new reality coming out of the COVID-19 pandemic, there is a clear necessity in this moment to rethink how to rebuild the global economy and societies for a more resilient and sustainable future. Governments around the world are turning to infrastructure as they embark on economic recovery plans to boost growth.

Now there is a need for sustainable revival focused on adaptation and mitigating climate change. This means prioritizing green infrastructure projects to ensure the country emerges from the COVID-19 crisis more resilient to address imminent threats. Furthermore, the World Bank had forecasted that economic losses from disasters are expected to rise further because of rapid economic growth, urbanization and the growing concentration of people and assets in cities.

Blue-Green Infrastructure (BGI) guidelines are necessary to improve resilience against calamities and prevent massive economic losses caused by natural disasters. The World Bank further warned that developing countries in the region might be exposed to substantial impact on fiscal position, in terms of public expenditure, as governments shoulder an increasing financial responsibility for post-disaster recovery and reconstruction.

For the Philippines, the pandemic was a further blow to the country's already troubled urban fabric. It has exposed the country's constraints in understanding how people thrive in the city centers, particularly when Metro Manila took the brunt of the pandemic crisis. Limiting movement and space during the two-year lockdown exposed the lack of urban infrastructure to support the disconnect between people and basic necessities. Public transport became a privilege, and the limits set on service providers of necessities has rendered moot the policy of social distancing – since people will flock towards where they can survive, even if there's not enough space to go by.

# HOW TO USE THE HANDBOOK

This guide provides a framework for creating a locally tailored action plan for BGI planning and delivery. It introduces the basic concepts around blue-green infrastructure (BGI), presents the background referencing local context, and the main drivers that spur development towards BGI interventions.

It presents planning principles that help in decision-making.

It enumerates steps, tips, and case studies that are best practice examples of BGI implementation.

It shows different typologies and application of planning principles in different scales.

# THE NEED FOR A BGI HANDBOOK

**Main Objective.** The main objective in developing this Blue-Green Infrastructure Handbook for Biodiversity is to empower stakeholders in creating and maintaining a sustainable urban environment through blue-green infrastructure to promote biodiversity.

**Goals.** This BGI handbook developed with the following goals in mind:

- To serve as the basis for the development of policies in the National and Local Government for the implementation of blue-green infrastructures and as a guideline for implementing BGI projects;
- To help identify and understand the role of different stakeholders/sectors in implementing blue-green infrastructure in the Philippines;
- To provide the localized standards for blue-green infrastructure in the Philippines; and
- To provide pathways to mainstream blue-green infrastructures that are applicable in the Philippine urban context.

**Importance of Urban Biodiversity**. The ecologist Christopher Swan once said, "These ecosystems are vital, but biodiversity can also be found in a variety of other places" (Swan, 2017 June 27). Indeed, there is a virtual misconception that biodiversity exists in a certain way, like a heavily dense tropical rainforest in far-off mountains or a lush wildflower grassland while cruising along a rural area. For thousands of years human civilization has formed large communities that had carved its mark on the surface of the Earth, giving rise to many man-made alterations that characterize our planet today. These have evolved into the cities and the urban environment where more than half of the world's population resides - and this figure is soaring. Therefore, it is important to understand that despite these substantial environmental changes that humans have caused, research shows that urban spaces are still rife with many forms of life and there is a way that we can develop and maintain habitats to support them.

Currently, stakeholders' raised expectations on the level of service that they deserve from their urban environment are fueling the need for improvement of their community. It is past time for policy makers and urban dwellers to consciously invest in urban development and the biodiversity of the urban spaces they inhabit.

**Role of Urban Biodiversity**. Climate change and environmental degradation are the main factors pushing urban areas towards BGI solutions to improve climate resilience and restore the health of ecosystems, which in turn improves the physical and mental well-being of residents.

Burgeoning importance of urban biodiversity has triggered an interest in the species that remain in disturbed urban environments and how they should be perceived. The general assumption being they are sparse, but in fact, there are many "*pockets of biodiversity in and around cities, such as frogs living in stormwater detention ponds and trees in restored streamside forests. Landscapes that people create in and around their homes support many ornamental herbaceous and woody plant species. Urban ecosystems present an opportunity to assess ecological communities in the context of unprecedented environmental change. It gives an opportunity to study and understand the relationship between people and urban biodiversity patterns*."

**Policy Gaps.** Lastly, the purpose of this handbook is to bolster the knowledge base for BGI in the country to better inform decision-making, gain political commitment at all levels, secure funding and private sector engagement, and ultimately advance its implementation. Much knowledge on BGI is produced in the global North, overlooking the diversity of urban contexts globally. As a result, less is known about urban BGI solutions applied on the ground to address

key environmental issues and challenges in developing countries (Reynolds et al., 2017; Brink et al., 2016; Connolly et al., 2014). Here, literature on BGI urban renewal in Southeast Asian cities will be reviewed to understand the scope of practical knowledge and identify research needs. The body of literature on BGI in Southeast Asia is small and dominated by wealthier countries, but it is hoped that this will help expand the region's knowledge base and bridge knowledge gaps within the country, promoting efficient BGI strategies with the appropriate context.

## PROMOTING BGI FOR CAPACITY-BUILDING

This handbook on blue green infrastructure was created to help communities, cities, towns, and regions plan for better visibility and usefulness of green-blue infrastructure in their urban areas, to serve as a guide in identifying opportunities to implement blue-green infrastructure at all scales, to develop evidence-based policies at any scale, and to prioritize key programs and projects.

This guide will aid the government, partners, and stakeholders at the local and the national level in forging the core elements of a blue green infrastructure action plan to drive their urban development initiatives.

## BGI HANDBOOK AS AN ACCESSIBLE EDUCATIONAL MEDIUM

The handbook is also intended to be a medium to teach and explain BGI to stakeholders in a concise and easily digestible manner.

The UN Convention on Biological Diversity (CBD), whose function is to be the *"international legal instrument for the convention of biological diversity*," is affirmed by at least 196 countries – including the Philippines. As such, the country has committed to certain time-bound obligations for a more sustainable future (PBSAP 2015-2028). In compliance with these obligations, the country formulated the 1997 National Biodiversity Strategic Action Plan (NBSAP), which under Article 6 of the Convention is the principal instrument for implementing the Convention at the national level. This handbook on BGI, in accordance with the provisions in the Philippine Biodiversity Strategy and Action Plan (PBSAP) implementation, aims to help bridge the biodiversity financing gap by mainstreaming biodiversity measures that can encourage the national government to funnel funds for its implementation through its relevant agencies.

Fiscal tools such as stormwater fees or rates, grants, rebates, and installation finance may be employed to encourage the implementation of BGI practices on public and private properties and on new and existing developments (or retrofits). These fiscal tools are easy to implement, as they provide decision-makers with the flexibility and creativity to tailor programs to specific priorities or to geographic areas in a community. These also enable a city to focus its resources and program efforts on a more manageable scale and can provide the opportunity to pilot new incentives to determine the potential for city-wide application (Brears, 2018).

# FAMILIARIZATION WITH THE TERMS

## URBAN BIODIVERSITY

Biological diversity, or biodiversity, refers to the variety of life in the world, in all its forms and all interactions. All living things live together and have myriad of connections with one another, forming complex networks of interdependent relationships called ecosystems. Healthy ecosystems provide benefits that is vital to the survival of living things and help us cope with the impacts of climate change. Human survival is dependent on biodiversity. Hence, biodiversity is the key indicator of the health of an ecosystem.

Fig. X.X. Vegetated riparian zones.

## BLUE-GREEN INFRASTRUCTURE

**Green Infrastructure.** Green infrastructure is defined as an interconnected network of multifunctional green spaces which together maintain and enhance ecosystem services and resilience, providing multiple functions and services to people, the economy and the environment (Tzoulas et al., 2007; Naumann et al., 2011; European Commission, 2012a). It describes a process that promoted a systematic and strategic approach to land conservation at the national, state, regional, and local scales, encouraging land-use planning and practices that are good for nature and for people. It is an approach that protects and restores natural ecosystems – such as mangroves, coral reefs, and seagrass – that provide protection to the communities near them.

**Blue Infrastructure.** Blue infrastructure relates to urban water infrastructure, including ponds, lakes, streams, rivers, wetlands, flood plains, water treatment facilities and storm water provision. Sustainable drainage schemes are usually included under this heading but are sometimes also labelled as green infrastructure.

**Blue-Green Infrastructure.** Blue-green infrastructure (BGI) is an innovative new approach opted by many cities and urban areas to combat climate change and environmental degradation with the help of sustainable interventions. The idea primarily focuses on urban flood resilience and aims to restore the health of ecosystems. Combining Green and Blue elements together is effective in providing a sustainable natural solution to urban and climatic challenges. Vegetation assists with air pollution removal, storm water management and heat island effects as well as creating places which are more pleasant and less stressful to live in.

# WHAT DO WE GET FROM BGI?

A key aspect of BGI is its multi-functionality, specifically its ability to deliver a wide range of environmental, economic, and social benefits, including improved water quality, within the same spatial area. This means BGI harnesses the interrelationships between vegetation and the water cycle to improve living conditions in cities. In turn, this enhances both sustainable development and water- and greenery-related ecosystem services. This is a central concept to achieve adaptation to the effects of climate change since it includes measures or actions to reduce society's vulnerability and to expand resilience capacity (IPCC, 2007).

This is based on the ability of BGI to deliver multiple services, providing environmental and cultural benefits and at the same time contributing to climate change adaptation and mitigation (Kabisch et al., 2016). Therefore, BGI can create win-win situations, and thus several cities use these measures as cost-effective and integrated climate adaptation solutions (Liu and Jensen, 2018; Miller and Montalto, 2019).

BGI provides multiple environmental, social, and economic benefits. It aids in urban drainage and stormwater management by capturing and cleaning stormwater surface runoff, improving the water quality and ensuring the ecological health of waterways. BGI also reduces the potential for flooding by slowing down and detaining stormwater, allowing it to percolate into the ground. By regulating local hydrological conditions, BGI can improve the resilience of communities and natural habitats to climate change. BGI also helps regulate temperature, air quality, and noise in urban areas. It can improve urban biodiversity by improving the quality of wildlife habitats. BGI can become part of the ecological network of a region, serving as auxiliary ecological corridors which increases landscape permeability, thereby improving the resilience of wildlife metapopulations. This increase in space for communities and wildlife creates more sanctuaries for urban wildlife pollinator species.

These environmental benefits cascade into social and economic benefits. BGI provides physical and mental health benefits by mitigating pollution and providing greenery in cities which help reduce stress. The presence of urban greenery also increases property values and create local distinctiveness. BGI is also well-positioned for integration with transport and energy solutions.

BGI can reduce infrastructure costs.by reducing the volume of water entering urban sewer systems, which increases the lifespan of sewers and reduces maintenance costs. Deploying blue-green infrastructure in sectors such as transportation, water and housing can result in various provisioning, regulating, supporting and cultural ecosystem services, which in turn lead to health and environmental improvements alongside financial savings (Observer Research Foundation, Issue No.317, 2021 p. 3). BGI also creates more opportunities for tourism and recreation, as well as for job creation and local economy diversification.

# DEVELOPING THIS HANDBOOK

## LITERATURE AND POLICY REVIEW

Development of the BGI handbook began through the compilation of scientific literature related to BGI and its concepts and guiding principles. Such material included science journal articles and books discussing the design, benefits, and limitations of BGI and related concepts. Several local and international policies on BGI were also compiled. Once compiled, the BGI handbook consultants compared the literature for similar and conflicting themes, ideas, scopes, and applications.

## CONSULTATIONS

Following the literature and policy review, the consultants presented the initial draft to stakeholders from various backgrounds, including national government agencies, environmentally oriented non-government organizations (NGOs), community-based environmental groups, business groups, people's organizations, and the academe through focus group discussions (FGD) and key informant interviews (KII).

The consultants also reached out to several groups and people to inform the development of the handbook. On the handbook development process itself, they consulted with the technical working group of the University of the Philippines Biodiversity Handbook, headed by L. Arch. James Buño. They also sought the insights of experts on biodiversity and policy formulation, Mr. Lorenzo V. Cordova, Jr. and Ms. Olga C. Lomboy, respectively.

Opting to conduct a case study on BGI in the Philippines, the BGI handbook consultants interviewed the lead landscape architects of two Philippine BGI projects: L. Arch. Paulo G. Alcazaren for the Iloilo Esplanade, and L. Arch. Vic L. Dul-loog for New Clark City River Park.

## RESEARCH LIMITATIONS

The consultants developed this BGI handbook in 2021 to 2022 during the global COVID-19 pandemic. To observe physical distancing protocols and prevent cross-infection, the consultants conducted all FGDs and KIIs through online conferencing tools.

## TIMELINE OF ACTIVITIES

Handbook development commenced in September 2021. After writing and revising initial drafts, the consultants held an FGD with several stakeholders on December 14, 2021, with the technical assistance of DENR-CAWED. As they revised the draft, the consultants held several FGDs and KIIs between late January to early February 2022.

# APPLICATIONS OF BGI

## BIODIVERSITY

Developing nature-based solutions and holistic approaches address the main direct and indirect causes of biodiversity loss. This knowledge will enable us to design the best ways to protect and sustainably restore ecosystems - currently under pressure on several fronts. It will also preserve their capacity to deliver a wide range of essential services on land, inland water and at sea, including solutions to reduce greenhouse gas emissions and to adapt to the changing climate.

Pursuing sustainable development involves seeking positive improvements in the quality of the natural environment, including moving from a net loss of biodiversity to achieving net gains for nature.

Local plans should include a strategic approach that plans positively for the creation, protection, enhancement, and management of networks of biodiversity and green infrastructure.

## CLIMATE CHANGE AND DISASTER RISK REDUCTION

Nature-based solutions represent a critical concept that harnesses natural systems to provide essential services for disaster risk reduction and climate change adaptation. As a nature-based solution, blue-green infrastructure takes advantage of nature's innate ability to substitute for or strengthen infrastructure systems by preserving, enhancing, or restoring a natural system's elements to build high quality, resilient and lower-cost infrastructure (Uy & Tapnio, 2021).

The use of, "*rain cisterns, permeable pavements, vegetative swales, green roofs, and bio-retention…* (Hu et al. 2019)." led to the reduction of runoff, reduced the overall area that floods occurred over, and reduced total flood volume during a flood (Baek et al. 2015; Hu et al. 2019; Hu et al. 2017; Mei et al. 2018). these methods according to Eckhart et al. 2017 found that the use of such low-impact development flood prevention measures could result in monetary saving of up to 80% when compared to the hard engineering methods of flood prevention (Eckhart et al. 2017).

The retrofitting of urban space with low-impact green infrastructure was relatively practical and resulted in a maximum surface runoff reduction of almost 60% (Hu et al. 2019). They, however, due note that these methods do have their limitation with their effectiveness being reduce in short, but heavy rainstorms and in some instances can have capacity limitations (Hu et al. 2019).

## HABITAT AND WILDLIFE CONSERVATION

Habitat improvement and channel enhancement are important measures to increase hydromorphological and biological WFD status and improve the catchment for BAP species.

Promote the preservation, restoration and re-creation of priority habitats, ecological networks and the protection and recovery of priority species populations.

## WATER MANAGEMENT

**Water Supply and Sanitation.** Watersheds improve source water quality and thereby reduce treatment requirements. Wetlands filter wastewater effluent and thereby reduce wastewater treatment requirements.

**Hydropower.** Watersheds: Reduce sediment inflows and extend life of reservoirs and power plants.

**Coastal Flood Protection.** Mangrove forests: Decrease wave energy and storm surges and thereby reduce embankment requirements.

**Urban Flood Management.** Urban flood retention areas store stormwater and thereby reduce drain and pump requirements.

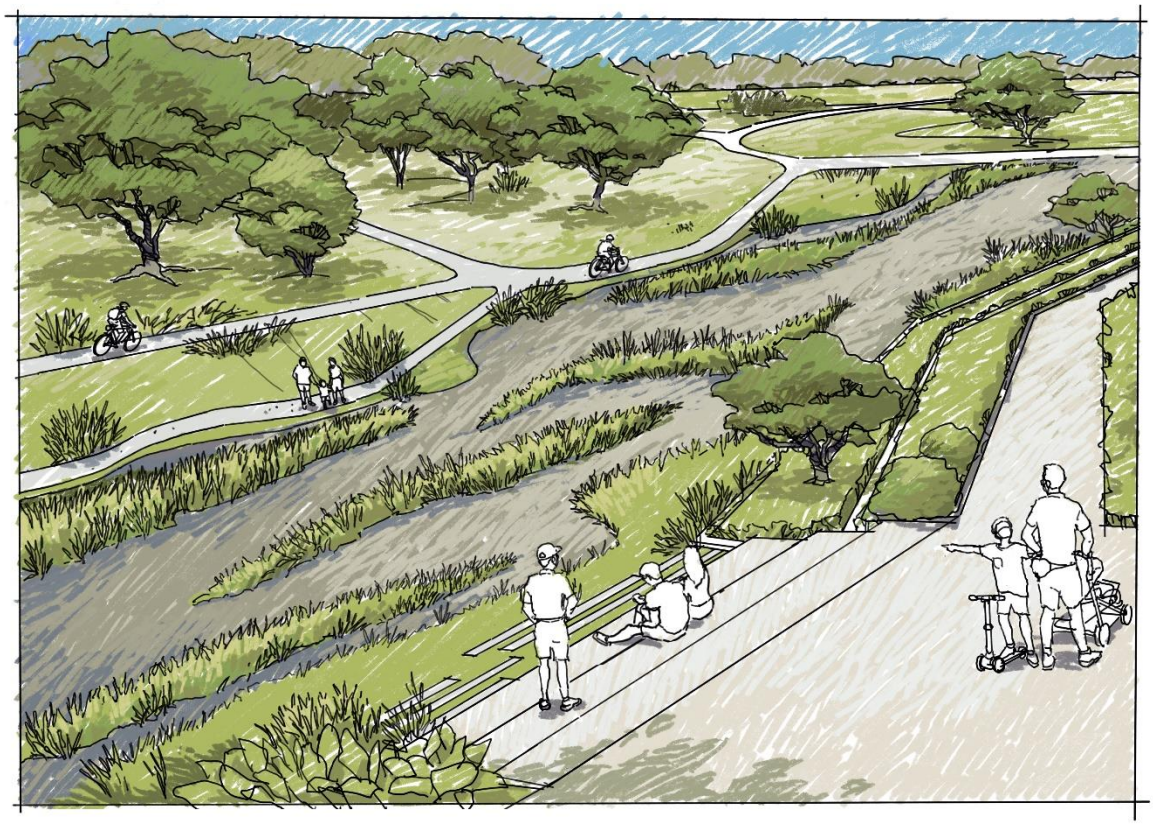

Fig. X.X. Green spaces in floodplain.

**River Flood Management.** River floodplains: Store flood waters and thereby reduce embankment requirements

**Agricultural Irrigation and Drainage.** Agricultural soils: Increase soil water storage capacity and reduce irrigation requirements (Browder et al, 2019).

## ENERGY

**Urban Metabolism.** Developing a model that can provide insight in a cities resource flow, to inform resource efficient design of our cities. To plan and design resource efficient cities, a sound understanding of urban resource flows is essential (Voskamp et al., 2016). One of the approaches used to analyze resource flows in cities is urban metabolism. Urban metabolism refers to the exchange processes whereby cities transform raw materials, energy, and water into the built environment, human biomass, and waste (Decker et al., 2000). It is argued that urban metabolism analyses can contribute to sustainable urban planning and design, but thus far this application remains limited (Kennedy et al., 2011).

### TRANSPORTATION

Interconnected systemic factors important for the flow of benefits: the layout and intersection of infrastructures, including BGI and transportation networks

BGI's functionality and contribution is dependent on the urban system it is embedded.

Transportation may cause environmental problems (e.g., anthropogenic contaminants in storm water, barriers to species' movements, and emission of particles), creating a place-specific need for certain economic services.

The function of BGI is to prevent the spread of negative externalities across other infrastructures.

Transportation networks and modes of transportation often offer a better approximation for how available BGI and ES benefits might be (e.g., Van Herzele and Wiedemann 2003).

## GUIDING PRINCIPLES OF BGI

### GENERAL SYSTEMS THEORY

General systems theory (GST) is a holistic analytical approach that delves in the concept of systems. A system is a group of interacting, dependent elements that form a complex whole. GST highly differs from reductionism, a linear analytical approach that assumes a whole system can be explained from knowledge of its parts. While straightforward, such linear thinking does not consider the complexities that arise from the interactions between each component of the system. In GST, the whole system is acknowledged to be *"more than the sum of its parts"*. It acknowledges the complexities that arise from interactions between system components, giving rise to emergent properties, or qualities of a system that can be observed from the whole system, but not from its individual components (Montuori, 2011).

Systems describe the input, processing, and output of "stuff" such as materials, energy, and information.

One can characterize the behavior of resources and information in a system where outputs are reintroduced into the system as inputs, creating feedback loops. A feedback loop that processes stuff at increasing or decreasing rates per iteration is said to be a positive feedback loop, also known as a self-reinforcing loop. One wherein the rate of change stuff oscillates between increase and decrease is said to be a negative feedback loop, or a self-limiting loop.

A system may be categorized as open or closed. Open systems allow the import and export of stuff across system boundaries, regardless of whether the system recycles its stuff through processes within the system. Closed systems do not import and export stuff, are isolated from other processes beyond its system boundaries, and almost solely feature only internal processes. All ecosystems in planet Earth are considered as open systems, as they rely on external inputs such as sunlight and nutrient deposits and output stuff such as heat and nutrient-rich surface runoff to other ecosystems. The planet Earth itself may be considered a closed system because, the total energy and mass of resources in the system remains the same except for the insignificant mass that meteorites and space debris entering the atmosphere introduce.

Holistic thinking, also known as systems-thinking, recognizes that because systems are complex and often interconnected or even interdependent with other systems, there is always some degree of stochasticity, unpredictability, and uncertainty in any given system.

## RIDGE-TO-REEF APPROACH

A holistic approach to environmental management, the ridge-to-reef approach recognizes the functional interconnectedness of ecosystems, regardless of physical proximity or distance. Processes in coastal ecosystems can influence the functions of montane ecosystems, and vice versa. With a ridge-to-reef approach, one considers the ecological flows and impacts of a given development to all ecosystems, from deep marine ecosystems to coastal mangrove forests and up to mossy montane forests at the highest summits of mountains.

## LANDSCAPE ECOLOGY

Landscape ecology is the branch of ecology that studies the dynamics between ecological processes and spatial configuration. There is great emphasis on the concepts of landscape connectivity, or the degree of linkage between different ecosystems and habitats, and of landscape heterogeneity, the variability and diversity of cover types in a landscape.

**The PCM Model.** The Patch-Corridor-Matrix model (or PCM model) refers to the structural elements that comprise a heterogeneous landscape. The landscape matrix refers to the most dominant and extensive type of habitat or cover type. The matrix has high connectivity and exerts tremendous influence upon other less dominant cover types in the landscape. Landscape patches are habitats or cover types that differ from its surroundings in terms of nature or appearance. Landscape corridors are relatively narrow strips of a habitat or cover type. It differs in nature or appearance from areas adjacent to both of its sides. Together, patches, corridors, and matrices form a landscape mosaic, the configuration of which will be unique to every single landscape.

**Drivers of Landscape Pattern Formation.** Every landscape is unique. The interacting effects of multiple environmental drivers and controls generate a landscape that is unlikely to be duplicated at any other time or location. Landscapes may vary in composition and spatial configuration. Composition refers to how much of each habitat or cover type is present. Meanwhile, spatial configuration refers to the specific arrangement of these spatial elements. The composition and spatial configuration of a landscape can greatly influence how its ecological processes function. Thus, it is important to understand how these landscape patterns are formed. We can categorize the drivers of landscape pattern formation into 4 types: abiotic conditions, biotic interactions, natural disturbances and succession, and human land use.

Turner and Gardner (2015) categorized drivers of landscape pattern formation into four (4) types: abiotic conditions, biotic interactions, human land use, and disturbance and succession.

Abiotic conditions can be thought of as a "template" upon which other drivers may influence how a landscape pattern is formed. Climate and landform are two categories of abiotic conditions that drive the formation of patterns in a landscape.

*Climate* acts as a strong control on biogeographic patterns by determining the distribution of water and energy. There exists variation in general climatic patterns, wherein climate varies with latitude, influencing temperature and moisture distribution. Topography then modifies these large-scale climatic trends at a finer scale to produce microclimates.

Referring to the characteristic geomorphological features of a landscape, *landform* results from geologic processes that produce patterns of physical relief and inform soil development. It can

be described through many characteristics, such as (1) The relative *amount of gently sloping land*, defined as slopes that are less than 8%; (2) *local topographic relief*; (3) *Generalized profile*, or where and how much of the gently sloping land is in valley bottoms or in upland areas; (4) the *soil catena*, or the topographic sequence of variation of soils; and (5) *associated vegetation types*.

Landform can exert several general effects on ecosystem patterns and processes. For instance, it affects temperature and material quantity. Specifically, the elevation, aspect, parent material, and slope of the landform influence air and ground temperatures, as well as the amount of material such as moisture and nutrients in the ecosystem. Landform affects the flow of quantities such as organisms, propagules, energy, and matter through a landscape. It affects the frequency and spatial distribution of fire, strong winds, grazing, and other natural disturbances. Finally, it constrains the spatial pattern and the rate of frequency of geomorphic processes that alter biotic characteristics and processes. An example of these geomorphic processes is the mechanical transport of organic and inorganic material.

Together, the overarching influence of climate modified by landform results in fine-scale heterogeneity in landscapes.

**Landscape Patch Dynamics.** Shape, size, orientation, proximity, adjacency, and many characteristics of landscape patches influence its biotic processes, especially population and community dynamics.

Two models on population dynamics form the backbone of our current understanding of landscape patch dynamics: island biogeography theory and the metapopulation theory.

The island biogeography theory was developed initially to predict the number of species found on oceanic islands. The theory suggests that the number of species on an (oceanic) island is affected by island size, isolation, and immigration and extinction rates. The number of species on an island, or species richness, is positively correlated to island size. Larger islands tend to host more species because species richness increases with habitat area. Species richness is negatively correlated to distance from the mainland, which acts as a source of new colonists, or species from the mainland that can travel to and take up residence in one of the islands. Hence, there will be fewer species on islands that are further away from mainland. Species richness also is dependent on the immigration rate, or how many species enter the island at a time, and the extinction rate, or how many species disappear from the island at a time.

The theory was then adapted for use in alpine zones, wherein habitats on mountain peaks were alluded as “sky islands” in an “ocean” of lowland habitats. Eventually, the theory was used as a framework for habitat fragmentation research and nature preserve design. There was a debate on whether to design for a single large nature preserve or for multiple smaller preserves. Whereas single large preserves could hold more species at the expense of increased susceptibility to total extinction by a single catastrophic event, multiple smaller preserves will contain less species per preserve but will be more resilient against the same catastrophic events.

The metapopulation theory deals with the concept of *metapopulations*, the interconnected set of populations that function as a larger demographic unit. All populations will eventually go extinct. Populations have a finite probability of extinction. This probability may be very small but never zero. The smaller the population, the more likely it may become extinct. However, if the population exists as a patchwork of subpopulations, then recolonization may occur between subpopulations. This rescue effect allows the species to persist at broader scales through recolonization despite the inevitability of local extinctions.

From the two theories, landscape ecologists since then have refined their research, leading to more nuanced understanding of landscape patch dynamics. Of note is the concept of patch edges and interiors, ecotones and the edge effect.

"Edge" refers to the areas near and along the perimeter of a habitat or cover type. Edges in patches and corridors are the parts most exposed to the effects of adjacent areas, notably of the matrix. Patch interiors are the areas furthest away from the edge, hence are less impacted by the effects of habitats adjacent to the patch. Increasing patch size exponentially increases the interior area of the patch.

No naturally occurring habitat has a defined edge. Transitions between two different habitats or cover types will always be gradual. Ecotones are these transitory gradients between two habitats. Both habitats exert their influence across the ecotone, thus lending it their characteristics. Thus, this transitory zone exhibits an edge effect, wherein it hosts species from either habitat or cover type, as well as species that thrive exclusively within the zone, resulting in high biodiversity within it.

**Landscape Matrix.** The sheer magnitude of the landscape matrix relative to the rest of a landscape allows it to significantly impact the distribution patterns and behavior of various wildlife. For example, in an investigation of the landscape matrix on planthoppers' movement patterns, Haynes and Cronin (2006) released individual planthoppers at the edge of brome- and mudflat-covered cordgrass patches and within the homogeneous habitats of each type. They found the planthoppers to move more linearly through mudflats. In contrast, the planthoppers' movement was more tortuous in patches with host and nonhost grasses.

Hodgson et al. (2007) also investigated the movement of birds across habitat edges, at the interface between remnant bushlands and two densities of suburban housing. They found that omnivorous & nectivorous birds were more likely to penetrate through edges near high-density housing, while insectivores were more likely to penetrate through edges near low-density housing. The researchers purported characteristics of the landscape matrix, namely the proportion of housing and variables associated with shrub and canopy vegetation, may influence these trends. With appropriate management of the housing matrix, many species crossing at these habitat edges may have the potential for dispersal.

From both studies, it is evident that understanding the impacts of landscape matrices on wildlife behavior is necessary for the maintenance of meta-populations and the prevention of local extinctions.

**Connectivity and Fragmentation.** Connectivity and fragmentation refer to the degree of linkage between habitat patches, especially in the context of human-disturbed landscapes. It is important to distinguish *habitat loss*, the disappearance of total habitat area, from habitat fragmentation, which refers to the breaking up of those habitats (Fahrig, 2003).

Retaining remnant trees and vegetation works best for increasing species richness in urban developments (Barth et al., 2015).

Yu et al. (2012) proposed a methodology for planning spatially explicit conservation networks, described in four steps. First step is to identify any remaining natural and semi-natural area as ecologically prime areas, which will be areas of strategic importance for conserving flora and fauna and for maintaining high environmental quality to promote the well-being of people and biota alike. The second step is to evaluate the overall connectivity of core habitats and to identify what landscape pattern context was the most important to the conservation network. This step entails integration with graph-theoretic models. For step three, one would suggest an ecological corridor system to both improve ecological connectivity and facilitate a livable environment, The step focuses on maximizing the ability to utilize existing conditions to reduce construction costs while meeting the ecological aims of the network. Finally, step four entails the development of a comprehensive optimization scheme to be suggested for the overall conservation planning.

## DISTURBANCE

**Ecological Succession.** The structure and processes of any ecosystem is subject to change. Newly formed ecosystems such as those forming after volcanic activity creates new land transitions from a less complex to a more complex community structure. Such a dynamic is called ecological succession, wherein an ecosystem develops and changes from a state of nonequilibrium to a state of equilibrium. Habitat patches with similar species composition but in varying stages of succession will feature differences in community structure. These variations become possible due to disturbances (Grigg, 1983).

**Intermediate Disturbance Hypothesis.** The intermediate disturbance hypothesis is a concept developed to explain how an ecosystem experiencing moderate levels of disturbance exhibit greater species richness. An ecosystem subject to too much disturbance will be unable to reach a later stage of succession. Because only r-selected species can thrive in these volatile conditions, a highly disturbed ecosystem will exhibit low biodiversity. However, with little disturbance, an ecosystem reaches a state of equilibrium where long-lived K-selected species thrive and outcompete most other species, resulting in relatively lower biodiversity, as well. Meanwhile, an ecosystem subject to disturbances of moderate intensity and frequency allow a wider range of r- and K-selected species to thrive, resulting in high biodiversity.

**Resilience.** In the context of ecosystems, resilience is the inherent ability of an ecological system to absorb disturbances & reorganize while undergoing state changes to maintain critical functions. Urban resilience is the ability of an urban system to maintain or rapidly return to desired functions in the face of disturbance (Meerow et al., 2016).

The point where even small changes in environmental conditions associated with disturbances lead to a switch between ecosystem states is the ecological threshold of an ecological system.

There are two perspectives for managing ecosystems with respect to resilience (Sasaki et al., 2015). One is resilience-based management, or the management of predictable anthropogenic disturbance. This perspective entails maintaining a sufficient level of biodiversity to ensure ecosystem resilience. The other perspective is identifying ecological thresholds along existing or experimental disturbance gradients. This entails identifying indicators of proximity to thresholds and an understanding of threshold mechanisms. Both perspectives provide a scientific basis for management and conservation against stochastic and multiple disturbances, in that when resilience-based management fails, detecting thresholds can help prevent the crossing of said thresholds. These perspectives would allow us to develop practical solutions to cope with uncertainties.

One must also note the concept of dynamic equilibrium. Socio-ecological systems are never static, and always in constant change. Resilient systems are in dynamic equilibrium: always changing but remaining functional.

**Redundant Systems.** Associated with resilience is the concept of the redundant system, which feature two or more system components that deliver similar functions. In case of the loss of one of these components, the other components can take over the role of delivering those often-vital functions. For example, different species with overlapping niches can substitute for each other in terms of delivering ecosystem services, if one species becomes locally extinct. Walker (1992) wrote that it is a better conservation approach to maintain the integrity of ecosystem function than to focus on individual species. Conservation efforts should focus on functional diversity as much as for species diversity. Hence, one must prioritize conservation efforts for functional groups with little to no redundancy (Walker, 1992).

## ENVIRONMENTAL JUSTICE

The benefits that we derive from biophysical processes of ecosystems are always entangled with the social and political processes of our society (Ernstson, 2013). Urban development patterns and the management of urban ecosystems affect the generation of benefits from biophysical processes.

The distribution of ecosystem services varies across temporal and spatial scales. Hence, one must ask who in society would benefit from these ecosystem services.

**Value Articulation**. Value articulation is needed for biophysical processes to attain value in decision-making. One must define the standards of value that they use. For example, a piece of ancestral land is valued differently by indigenous people and land developers, and clean, breathable air has little market value but is immensely value for public health.

**Access to Green Space**. Green space promotes physical activity, psychological well-being, and the general public health of urban residents. Hence, the accessibility of green space for people regardless of socioeconomic status is an environmental justice issue. Distribution of access to green space disproportionately benefits communities that are comprised of more privileged race and social class (Wolch et al., 2014).

There are several strategies to increase supply of urban green space in park-poor neighborhoods, such as greening remnant urban land and reusing obsolete or underutilized transportation infrastructure.

Paradoxically, development of land into green space may also promote gentrification. The presence of green space can increase housing costs and property values, thereby attracting new and more affluent residents who can outbid or buy out underprivileged older residents on homes, resulting in the displacement of the less affluent people. Hence, it is vital to explore how to design green spaces that are "*just green enough*" (Wolch et al., 2014).

The enforced immobility of less privileged communities gatekeeps them from opportunities to access green space. The high mobility of the privileged allow them to afford moving out to better neighborhoods that provide better ecosystem services through green space. Meanwhile, the less privileged are left only with the choice to stay and put up with the health, safety, and environmental hazards of their current neighborhood (Łaszkiewicz et al, 2018).

## EMULATING INDISPENSABLE PATTERNS

Green infrastructure planning should emulate 'indispensable patterns' in both urban and rural landscapes (Carne, 2016). This principle provides a clear directive without being overly prescriptive – 'emulate' meaning 'an attempt to match' (or even surpass).

Strategies to achieve this include retaining, rehabilitating, and maximizing the size of natural vegetation patches, include more than one at any landscape scale, protecting and maximizing the width of water courses with vegetated corridors, providing for functional connectivity for key species between large patches, and providing small heterogeneous patches and corridors throughout developed areas.

## ALIGNING WITH STATUTORY LAND USE PLANNING

A complete integration of the green infrastructure planning process within the statutory land use planning process would involve a change in the legal framework of the jurisdiction under question. As this is unlikely to be practical, 'alignment' with the planning process is called for.

Alignment is much less prescriptive than calling for 'integration' and allows for some discretion with respect to strategy. It encourages and facilitates the use of non-statutory green infrastructure plans in the statutory land use planning process and allows for the development of regulatory frameworks for green infrastructure.

## SOCIAL PRACTICE THEORY

Social practice theory (SPT) has been proposed as a framework for understanding relevant communities and their needs, motivations, and capacities for contributing to the design and management of BGI (Lamond & Everett, 2019). SPT considers the things people do, to reflect upon why and how they do them–and the tools, technologies and infrastructure that could enable or frustrate, encourage, or discourage this and other forms of 'doing'.

It is a more useful framework in explaining willingness to volunteer. Demographics are not indicative of willingness to help maintain blue-green spaces, and active recreational users are most willing to volunteer in multi-purpose green space.

The SPT approach can inform engagement to create BGI design that is more suitable for communities and can inform engagement to encourage stewardship behavior.

## GREEN INFRASTRUCTURE PLANNING

According to Kambites and Owen (2006), green infrastructure is "*connected networks of multifunctional, predominantly unbuilt, space that supports both ecological and social activities and processes*" (2006, p.484). Ten general principles govern their view on green infrastructure planning (2006, p.488): comprehensive planning, information collation, holistic approach, linkage, community involvement, recreational needs, conservation, respect for the site, local distinctiveness, and sustainable funding.

Ultimately, their study emphasized "*distinguishing between mapping and green infrastructure planning*" (Kambites & Owen 2006, p.487), as well as the necessity to integrate mapping approaches within the green infrastructure planning process. An essential attribute to consider is connectivity as a crucial aspect of green infrastructure. This could come in different forms, but highlighted primarily is '*spatial connectivity*', which allows for movement throughout the green infrastructure; '*connectivity between social and ecological functions*', which maintains connectivity by securing benefits to the mutual advantages of functions (Kambites & Owen 2006, p.490); '*connectivity between human users*', whose influence may overlap, coincide, or conflict with green infrastructure uses and should therefore be considered at all appropriate planning stages; '*administrative connectivity*', which demands a partnership approach from multiple authorities and organizations since linear movement of wildlife, plants and people do not recognize administrative boundaries; and lastly, '*connectivity between different parts of the organization structure of local authorities*', which is essential in delivering the best benefits of green infrastructure planning, as it involves embedding green infrastructure planning in democratic and statutory planning systems. (Kambites & Owen 2006, p.494)

Rouse and Bunster-Ossa (2013) cited six planning principles that must become the guiding ethics of a project program: multifunctionality, connectivity, habitability, resiliency, identity, and return on investment.

One must work these principles into the green infrastructure planning process across different disciples and scales. Their study provided helpful tips on how these principles are applied across landscape scales and their approach in planning is to identify connectivity, emphasizing 'multi-scale linkages' in the site. It can be said that their take on green infrastructure planning

reflects a "landscape ecological perspective". This approach is further exemplified by their view that "*green infrastructure operates as part of a hierarchy of nested systems, each of which contains stocks of assets held together by interconnections (flows and interactions between systems).*" (Rouse and Bunster-Ossa, 2013, p.15)

Landscape ecology also shaped Quintas' take on delineating planning principles for green infrastructure. These principles are quantity, quality, continuity, and context.

Due to its multifunctionality, green infrastructure is a "*key entity in urban planning politics*" Thus, it must serve its function between three areas of sustainability: environment, society, and economy. Quintas laid out the efficiency principles above to help gauge the performance of a green infrastructure system or its individual elements.

He writes that green infrastructure planning must be done at two levels in metropolitan landscapes: (1) strategic urban green infrastructure for the entire metropolitan area and (2) operative urban green infrastructure at the municipal urban level. Each metropolitan area has its own unique character, needs, and potential, hence planning and design must consider the functions that the landscape aims to accomplish, and must then formulate specific strategies to maintain and appreciate its most essential socio-ecological elements (Quintas, 2015).

# IMPORTANT CONCEPTS FOR UNDERSTANDING BGI

## ECOLOGICAL NETWORK

Ecological networks consist of core areas, corridors, and buffer zones. Corridors create a permanent connection between core areas which helps reduce the effects of fragmentation in urban and other human-disturbed habitats. Wildlife crossings are a type of corridor that improve connectivity between habitats by facilitating the movement and migration of wildlife and plant species between core and adjacent areas. As such, ecological corridors are essential for the long-term survival of biological diversity. Stepping-stone patches are a series of small, individual habitat patches that still function as a corridor despite not being physically connected. Like wildlife corridors, stepping-stone patches facilitate wildlife to move and find shelter, food, or rest.

Protected areas should not be considered as islands that are safe from negative external effects. Hence, in an ecological network, core areas and connecting corridors are surrounded by buffer zones which protect or buffer the interior habitat against disruptive external influences. Buffer zones allow a smoother transition between core areas and surrounding land use, and their size and utility depend heavily on the needs of the specific ecosystem and its local population.

## GREEN BUILDINGS

Green buildings are a type of architecture designed and constructed with a goal of reducing consumption of resources and emission of pollutants.

**Green Roofs.** Reclaiming the roof decks of buildings as green space, green roofs are a type of green infrastructure that provide several environmental benefits such as thermal regulation, air pollution abatement, stormwater management, carbon sequestration, and noise reduction (Yang, Yu, & Gong, 2008; Getter et al., 2009; Jim & Tsang, 2011; Speak et al., 2014; Berardi et al., 2014; Whittinghill & Rowe, 2014; Jim, 2015; Berardi, 2016).

Green roofs are comprised of several components, also known as layers. Key green roof layers are the vegetation layer, the growth substrate, the drainage layer, and the waterproofing. The vegetation layer are the plants installed on the green roof. Plant species selection depends on their suitability with regards to the thickness of the growth substrate layer, which must be lightweight while still providing ample nutrients for vegetative growth. The drainage layer drains out excess water from the growth substrate to minimize issues with waterlogging and roof deck structural issues associated with the weight of water. The waterproofing layer protects the underlying roof deck from water damage, which is key to prevent the costly need of uninstalling the green roof to repair cracks and leaks in the roof deck. Other layers such as the filter fabric and the root barrier assist the other layers in providing suitable vegetative growing conditions while preventing structural damage by water (Vijayaraghavan, 2016; Oberndorfer et al., 2007).

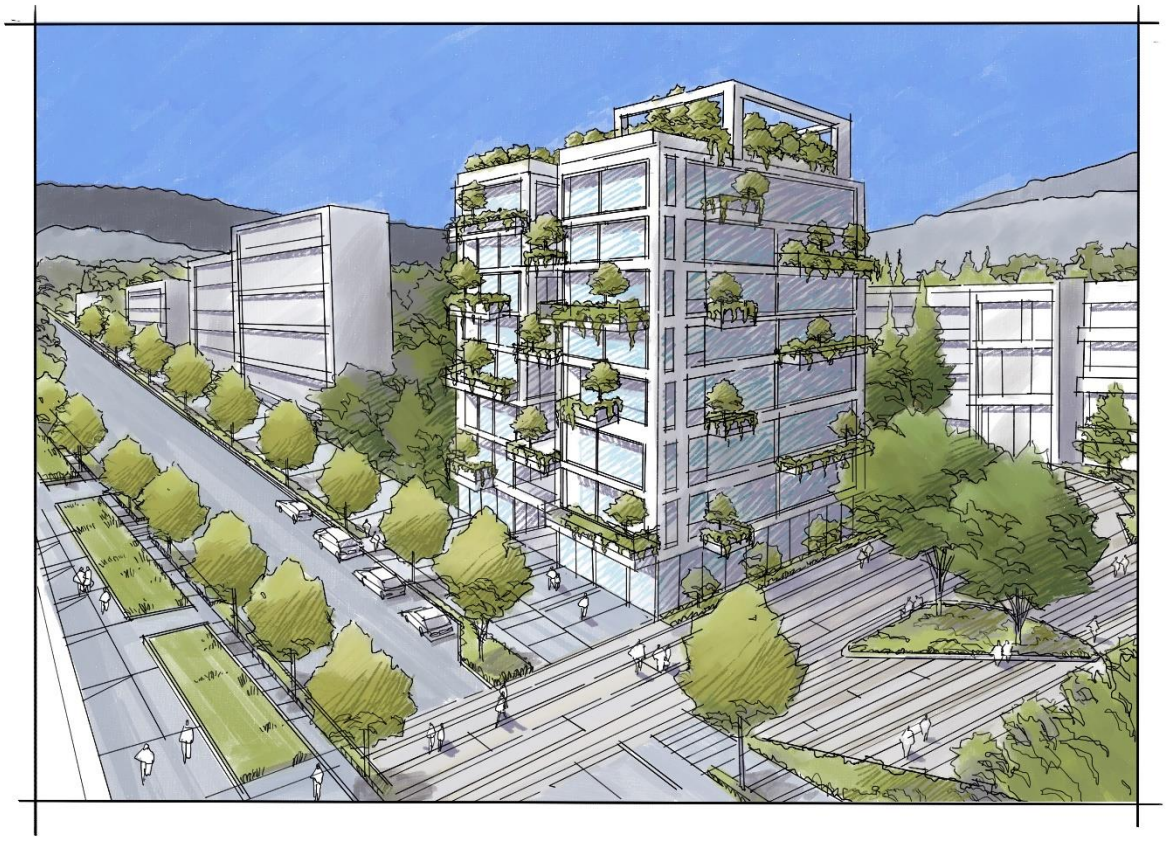

Fig. X.X. Green roofs and green walls.

The thickness of the growth substrate is often the basis for determining the type of green roof. Extensive green roofs have substrates that are less than 200 mm thick. This significantly reduces the structural load of the system upon the roof deck, making it suitable for retrofit works on older buildings. Extensive green roofs can only accommodate smaller plants such as succulents because of the limited substrate depth, but this may allow the green roof to persist from rainwater alone, hence requiring less maintenance. Intensive green roofs have substrates thicker than 200 mm, meaning it must be designed with structural impacts on the underlying roof deck in mind. Its increased substrate thickness allows intensive green roofs to accommodate larger plants such as shrubs and small trees, but in turn will require more maintenance and might need a built-in irrigation system. Semi-intensive green roofs are the intermediary between extensive and intensive types, as they contain features from both. Recent innovations have led to the development of more specialized green roof types such as blue-green roofs and hybrid systems between photovoltaic cells and green roofs (Berardi et al., 2016; Oberndorfer et al., 2007; Weiler & Scholz-Barth, 2009; Vijayaraghavan, 2016; Speak et al., 2013; Silva et al., 2015; Besir & Cuce, 2018).

**Urban Agriculture.** The concept of urban agriculture stems from the increasing pressures of food insecurity. Caneva et al. (2020) adds several principal aims to urban agriculture: environmental restoration, environmental education, and sociability and cultural value. Urban gardens can serve as genetic banks for several heritage and local varieties of plants (Riolo, 2019). An urban garden fosters the curiosity of city dwellers, exposing them to a greater understanding of ecological processes and how it benefits them.

Urban gardens can also contribute to developing a neighborhood community, place attachment, and meaning, creating sociability and cultural value (Riolo, 2019). Following catastrophic events such as earthquakes and extreme storm events, urban gardens can enhance social empowerment, provide safe gathering spots, and remind people of normality through

restorative practices (Shimpo et al., 2019). Facilities that encourage social interaction and bonding, such as central meeting and lunch places, and communal working areas serve as venues for de-stressing, sharing of experiences, and gaining community support, helping people cope with post-disaster situations.

Caneva et al. (2020) further proposed sustainability indicators for planning urban community gardens. These indicators can be grouped into three categories: (1) environmental parameters, which considers lot size and morphology, soil type, sunlight exposure, water supply, and biodiversity value; (2) risk factors due to local urban pollution from previous activities on site and the site's distance from heavy traffic roads; and (3) social context and accessibility of the site to schools, community centers, and other green areas.

## STORMWATER MANAGEMENT

Stormwater management entails a nature-based approach that is beneficial to local ecological functions, namely cleansing, detention, conveyance, and infiltration. Such an approach will treat stormwater not as waste but as a resource. Hence, stormwater management is most effective when integrated with the overall layout of cities.

**Ground Permeability**. Permeability is the property of the ground to percolate into the aquifer, a process that provides several benefits such as the rebalancing of groundwater level, stormwater cleansing, reduced peak discharge of groundwater, and reduced disturbance in streams.

## RETROFITTING GREEN AND OPEN SPACES

To improve their stormwater management capabilities, green and open space can be modified to work with local hydrology. Floodable parks are parks and recreation spaces designed as large runoff retention spaces within urban areas in a watershed. The Bishan Ang Mo-Kio Park in Singapore is a prime example of a floodable park. Similar to floodable parks, wet plazas are large floodable public open spaces designed for large retention capacity within denser urban environments. They are comprised of hardscapes with some vegetated areas that collect, detain, and retain stormwater to reduce flooding. They incorporate drainage connections to allow public spaces to return quickly to normal use. Enghave Park in Copenhagen, Denmark is a notable example of a wet plaza.

Fig. X.X. Floodable parks and plazas.

## TRANSPORTATION NETWORK

**BGI Design Typologies for Streetscape.** These design typologies will assist those planning, designing, constructing, and maintaining blue green infrastructure assets for streetscapes. Examples of such typologies are as follows (City of Melbourne Urban Water, 2015):

- Rectangular back curb raingarden
- Covered back of curb raingarden tree pit
- Large outstand raingarden
- Small outstand raingarden
- Bluestone channel raingarden tree pit
- Side of road passive irrigation tree trench
- Outstand with surrounding permeable pavement
- Permeable Footpath

## RESTORATION OF URBAN WATERWAYS AND WETLANDS

Urban waterways and wetlands can be restored and aesthetically enhanced. For example, riverbanks or coastal areas can be stabilized.

Roadways may be designed as a network of stormwater infrastructure. By channeling water away from buildings, cloudburst roads are designed to accommodate cloudburst, an extreme amount of precipitation in a short period of time. Unlike typical road crown profiles, a V-shaped road profile has its lowest elevation along the center of the road to encourage water to flow inwards and away from the sidewalk and the buildings.

Retention alleys are streets designed to detain water and reduce peak flow, protecting downstream areas from flooding. They are typically located upstream of low-lying areas vulnerable to flooding and allow conveyance of detained water into other infrastructure for stormwater management, such as permeable paving, stormwater planters, and rain gardens.

Featuring stormwater management features such as permeable paving, green streets are upstream connections to all cloudburst roads and retention alleys, creating a network of urban waterways.

## OTHER APPLICABLE AREAS OF INFRASTRUCTURE DEVELOPMENT

**Composting Facilities.** R.A. 9003 mandates segregation-at-source of biodegradable from recyclable and residual wastes. However, only 24.57% of all barangays in the Philippines had access to MRFs (*PSA, 2016).* As of 2014 to 2015, there were 42,036 barangays in the entire Philippines yet only 8,656 MRFs served 10,327 barangays. Composting allows the recycling of organic waste into humus, providing nutrient-rich fertilizer for small- and large-scale agriculture. More importantly, composting provides an alternative stream for organic waste, which would otherwise enter the municipal waste stream and contribute a bulk of total landfill waste volume. Composting minimizes the production of greenhouse gases, namely methane ($CH_4$) from anaerobic decomposition of organic waste in landfills, and nitrous oxide ($N_2O$) from the misuse of synthetic fertilizers for agriculture. Therefore, the provision of composting facilities empowers local communities to help address problems in solid waste management.

**Pollinator Garden.** Birds, bees, beetles, and even bats are some examples of wildlife that provide supporting ecosystem services in the form of pollination. Without pollinators, several species of plants will be unable to effectively reproduce, leading to the collapse of ecosystems. Pollinator gardens support pollinators in providing their vital ecosystem services.

Creating pollinator gardens entails selecting a variety of plant types that bloom at different times of the year to accommodate different pollinator species throughout the seasons. Hence, important in planning urban green space for pollinator conservation is phenology, or the study of the timing of recurring biological events (Vitorino et al, 2021). Variation in vegetation features such as plant height and flower morphology have a significant effect on pollinator species communities' composition (Dylewski et al., 2020). Thus, installing flowering plants with high variability in vegetation features in turn allows for variation in access to nectar and pollen from different pollinator groups.

A key consideration for pollinator gardens is to restrict landscape management practices that disturb and floristically modify potential pollinator habitats and resources (Dylewski et al., 2020). This means reducing lawn mowing frequency, minimizing built-up areas, and maximizing vegetation cover in the pollinator garden site (Baldock, 2020).

# CASE STUDIES OF BGI IN THE PHILIPPINES

## OVERVIEW

**Project Locations.** The Iloilo Esplanade is in Iloilo City, a 1st class highly urbanized city on Panay Island in the western Visayas region of the Philippines. Iloilo City falls under the Type I Philippine climate classification, characterized by a pronounced dry season from November to April, and a wet season for the rest of the year. To its south and southeast are the Iloilo Strait and the island of Guimaras. Iloilo Esplanade is situated along the Iloilo River, from New Carpenter's Bridge to Drilon Bridge.

The NCC River Park is in New Clark City (NCC), a planned community within the Clark Special Economic Zone in the Tarlac province. As with Iloilo City, NCC falls under the Type I Philippine climate classification. At its northeast is Tarlac City. At its south and southeast is Angeles City, Pampanga and the Clark Freeport Zone. Further southeast is Mt. Arayat and the Candaba Swamp. To its west is the rugged terrain of the Zambales province.

In terms of water bodies associated with both projects, Iloilo Esplanade is directly alongside the Iloilo River, hence is associated to the estuary downstream. The NCC River Park is directly associated with the Cutcut River that feeds into the Candaba Swamp.

**Project Figures.** Four kilometers of the Iloilo River was developed as the Iloilo Esplanade, with Phase 1 of its construction done for the 1st kilometer. The river system associated with NCC was around 10 kilometers long, but only the first 1.4 kilometers was developed. The NCC project site was 45 hectares in total, but only 5 hectares was developed.

Dul-loog estimated the budget for NCC to be at around PHP 5,000.00 per square meter (sq.m.), amounting to an estimated PHP 250 million budget for the entire development. In comparison, the Iloilo Esplanade cost only around PHP 600.00 to 700.00 per sq.m., and a total budget of PHP 68 million, according to Alcazaren. Funds for the esplanade were sourced from the pork barrel of Sen. Drilon, whereas ADB funded the NCC River Park. It is of note that the Iloilo LGU did not have to purchase additional lots along the Iloilo River for easements, as they already had procured most of them.

**Project Rationales.** The proponents of both the Iloilo Esplanade and NCC River Park recognized the hydrological significance of their respective site. According to Alcazaren, Sen. Franklin Drilon was able to leverage his political influence to convince the regional director of Region VI to provide funding for improving Iloilo rivers, after an international body had cited Iloilo City as a place that follows best practices for river cleanup during a conference.

BCDA sought to devote 50-60% of NCC as open space, majority of which were along the river systems, which are prominent in the site. They found that this percentage cannot be attained through streetscape alone. Hence, they considered the entire river system as a river park from the desire to protect the river edges.

**Entities Involved.** Franklin Drilon is an Illongo senator who first brought in Alcazaren as a landscape architectural consultant in 2013. Together, they coordinated with the Iloilo LGU, the acting client for the Iloilo Esplanade project. Prior to bringing in Alcazaren, Sen. Drilon had formed a task force to coordinate with project stakeholders, among which are mangrove advocates such as Dr. Jurgenne H. Primaevera, who were adamant with conserving the Iloilo River mangroves. The Department of Public Works and Highways (DPWH) served as the general contractor for the project.

The Bases Conversion Development Authority (BCDA) is a corporate entity created through Republic Act (R.A.) 7227 in 1992, with the goal of developing former military-owned real

estate for productive civilian uses, such as economic centers. BCDA held a design competition for NCC in late 2014 to early 2015, in which the multinational firm AECOM joined and won. AECOM produced an initial masterplan, which BCDA had a Malaysian firm revise. For funding, BCDA tapped the Asian Development Bank (ADB) who sought the services of a Japanese company for a hydrology study and of Pro-Seeds Development Association, Inc. for a biodiversity study of the project site. BCDA then brought in Dul-loog as a landscape architectural consultant for the planned NCC. Dul-loog, with the help of two experts, consulted with the indigenous peoples (IPs) of the affected area. Laurel Development Corporation served as the general contractor for the project.

## PROJECT HISTORY OF ILOILO ESPLANADE

**Pre-Design History.** Before Alcazaren handled the project, the banks of the Iloilo River were cleared of informal settlers. DPWH was asked to construct a dyke road to address the flooding problems of Iloilo City. After they noted the lack of vehicular traffic, the Iloilo LGU converted the dyke road into a promenade that lacked in shade and facilities and was paved in asphalt. Hoping to improve its current state, Sen. Drilon secured funding from the regional director of Region VI through his political influence. Then, in 2013, Sen. Drilon sought the services of Alcazaren, who previously was involved with several Singaporean riverscape projects in the 1990s. Drilon had also organized a task force for the stakeholders of the Iloilo River, from which Alcazaren and his design firm sought feedback for their landscape design. Primaevera and the other stakeholders already had begun their mangrove replanting initiative along the river, and all parties were aligned in terms of preserving the Iloilo River mangroves.

**Initial Design.** According to Alcazaren, their design for the 15-meter-wide esplanade in Phase 1 stemmed from the idea of *"[bringing] people closer to the water"*. He proposed *"several view decks with trellis seating and enough space"*. He also proposed kiosks (housing shops and utilities like toilets) and bicycle amenities and decided to install interlocking pavers over asphalt for the pavement.

While at first hesitant with the idea, the Iloilo mayor eventually allowed the provision of toilets and bicycle amenities. However, the kiosks were value engineered to be spaced further away than what Alcazaren intended. However, a kiosk serving as a café and convenience store did remain, as it was on private land.

**Design Development and Construction.** After Alcazaren worked on the esplanade design for 3 months, construction for Phase 1 commenced for 6 to 7 months, then was turned over to the Iloilo LGU. Later, Sen. Drilon asked Alcazaren again to handle the design for Phase 2. However, DPWH insisted that their department handle the project instead. During the construction of Phase 2, Alcazaren's firm was called only 3 times, during which they discovered DPWH had implemented the hardscape and softscape design differently. For instance, only 2 out of the 7 proposed decks were built. Alcazaren stated that at this time, because the department had yet to handle landscape architectural works, DPWH implemented only 50% to 60% of the design intent. Only the hardscape was constructed; the softscape had yet to be installed in the site. An investigation revealed *"strings being pulled behind the scenes"* regarding the project budget. Eventually, DPWH had to release the funds for the softscape because, Alcazaren noted, the project looked incomplete without softscape, despite them having finished the hardscape works.

From Phases 3 onwards, Alcazaren's firm was asked to work on the conceptual overview of the entire project. Design development and construction were handled by the Iloilo LGU, which by this time had learned how to implement open space projects properly with minimal assistance from the landscape design firm.

**Post-Construction Impacts.** The most significant post-construction impact of the Iloilo Esplanade was the four- to five-fold increase in property values of real estate along the Iloilo River. This, along with high public patronage and prestige for their city prompted the Iloilo LGU to seek Alcazaren's services for other projects in Iloilo City, such as the streetscape design for Aquino Avenue. Like their work on Iloilo Esplanade, Alcazaren's firm focused on the design and implementation for the first 2 kilometers of the avenue, to which the LGU referred for the rest of that project. These additional projects were all connected to the esplanade.

From these experiences, Alcazaren praised the Iloilo LGU for *"setting the bar high for publicly maintained open space."*

## PROJECT HISTORY OF NEW CLARK CITY RIVER PARK

**Pre-Design History.** BCDA held a design competition at late 2014 to early 2015, and its winner was AECOM, whose masterplan featured several highly built-up areas covering the river basin. However, when their goals for NCC shifted to be more ecologically sensitive, BCDA sought the services of a Malaysian company to revise the masterplan modelled after Putrajaya, Malaysia's government center newly built at the time.

**Initial Design.** A friend of Dul-loog who was associated with the project contractor, Laurel Development Corporation, asked him to join the team for Phase 1 which involved the development of the New Government Administrative Center (NGAC), located at the end point of the river system. In the first stages of consultation, Dul-loog and his firm developed a masterplan for the entire 45-hectare site. The development included streetscapes, a stadium, an aquatic center, and the government center. However, budget constraints reduced the scope of the project to only 5 hectares of the development.

With the desire to ensure the sustainability of the project they were funding, ADB commissioned a hydrology study of NCC to a Japanese entity and a biodiversity study to Pro-Seeds Development Association, Inc. Both studies recommended the conservation of existing flora, fauna, and hydrologic systems amidst development.

Aligned with these studies, Dul-loog's firm designed the NCC landscape to accommodate temporary flooding. Citing Bishan Ang-Mo Kio Park in Singapore as a model for their design approach, Dul-loog and his firm first considered the hydrology, flora, and fauna of the site before the needs of the human users. Hence, their landscape design features native trees and shrubs and open green space that can mitigate surface runoff volume. The open green spaces also doubled as venues for art installations, in line with the idea for NCC to be a "creative city". They also identified 4 river typologies for their landscape designs, based on proximity to other areas: (1) near housing; (2) near commercial centers; (3) near the central park; and (4) in protected areas.

Dul-loog had also consulted with the indigenous peoples (IPs) in the site with the help of two professionals in communicating with IPs. The IP consultations informed their initial landscape design proposal to emulate the IPs' systems. Their designs for the "storm hut shelters" and waste bins were inspired from the IPs' structures. They also had proposed to BCDA the idea of turning the site into a learning space of indigenous peoples' cultures, with the IPs as its guides. Additionally, the IPs would serve as caretakers overseeing maintenance for the site. However, although Dul-loog cited these to be aligned with BCDA's policies, the concepts they proposed disappeared during implementation.

**Design Development and Construction.** Throughout the planning process, Dul-loog found that for some people involved with the project, it was difficult to grasp the concepts of landscape ecology and BGI. He cited the engineers and project managers on-site to have been resistant to BGI concepts, notably the gabion walls, and controlled the disbursement of funds. Patronage politics put Laurel Development Corp. in a difficult situation for not availing the products of their

suppliers and associates. Fortunately, the BCDA chairman was receptive to the BGI concepts when Dul-loog presented the refined schematics. Because the chairman had the final say for approvals, the concepts pushed through.

During its 1-year construction period, the site was heavily flooded twice, both subsiding after 6 hours. Dul-loog expressed vindication when the rain events highlighted the effectiveness of BGI and its benefits for the development by improving the site's function as a "sponge" for mitigating surface runoff volume.

**Post-Construction Impacts.** Besides enhanced stormwater management, the landscape showcased several positive impacts post-construction. There was an observed increase in wildlife in the site, notably the heightened presence of different bird species, several of which were associated with the ecologically significant Candaba wetlands. Several people had patronized the space before the start of the COVID-19 pandemic, and more so during the global event. The pandemic also had forced the BCDA to cease landscape maintenance works to minimize infection between personnel, resulting in the senescence of several exotic plant species installed in the site for aesthetics. However, the native trees and shrubs that the planning team retained and introduced in the site survived without maintenance. These post-construction impacts highlighted the benefits of effective river park design in the Philippines, especially among the general populace, according to Dul-loog.

## SIMILAR EXPERIENCES BETWEEN THE KEY INFORMANTS

The landscape architects of both case study sites shared their experiences throughout the project life cycle. Both cited similar experiences on power dynamics, design implementation, project financing, the state of design professionals, and on dealing with stakeholders.

**Power Dynamics.** The power dynamics across hierarchical positions had impacts on the course of both projects. Alcazaren stressed that *"it's par for the course in government work that you are not in control."* He shared that although only 30% to 50% of the original design intent was implemented correctly, such values were favorable for a government project. He elaborated that LGUs tend to implement only about 20% of the design intent, based on his experience. Dul-loog experience was similar for NCC, wherein his firm found difficulty persuading various project colleagues on the benefits of BGI. It had reached the point where certain people in higher positions were limiting the flow of funds to those who refused to practice their patronage politics. Although the project eventually proceeded, much of the original design intent was lost, including several IP-inspired landscape design elements.

**Finances.** The unit cost of landscape design for Iloilo Esplanade was PHP 600.00 to 700.00 per sq.m.. In comparison, that of NCC was PHP 5,000.00 per sq.m. – at least 7 times the unit cost for the esplanade. This may explain the initial aversion of the NCC heads and some involved professionals towards BGI. However, Dul-loog persuaded them to "*look beyond the initial cost of the project and to look at the big picture*", namely the long-term benefits of BGI. He added that although maintenance will always be a factor in landscape development, using native plants can reduce maintenance effort, which was proven when only native plants in the site survived despite BCDA halting maintenance operations during the pandemic. Along the same line of thought, Alcazaren stated that convincing government officials to fund landscape projects could be done by showing them the relatively inexpensive cost of landscape design, which starts at around PHP 20 million, compared to that of a road or bridge, which starts at PHP 100 million. Alcazaren also emphasized the increased property values of real estate adjacent to the Iloilo Esplanade as a benefit for the Iloilo LGU.

**Professionals in Key Positions.** Both landscape architects underscored the need for professionals in important positions to improve landscape project implementation. Dul-loog said

projects employing BGI concepts would proceed more smoothly for designers if the people in higher position can easily grasp said concepts, as with how the BCDA chairman's approval helped move the project forward despite resistance to the concept of gabion walls. Regarding projects in Iloilo, Alcazaren envisioned local Illongo landscape architects to man the plantilla positions of the planning department and to oversee future projects of the city. He stated the idea after sharing his frustrations with DPWH, which at the time had no prior experience in handling landscape projects.

**Stakeholder Participation.** In his interview, Alcazaren presented a pragmatic take on stakeholder participation in the design process. He lamented that much of stakeholders' inputs will be too general unless they can be oriented and given the same language for design communication. He added that such issues were also evident among non-design professionals in LGUs. Moreover, he said there are challenges in terms of how Filipinos tend to be shy and might not respond much during orientations, and of LGUs preferring to expedite a project, leaving little time for an orientation. However, Alcazaren remained optimistic in saying, "*However, so long as there is a modicum of design inputs, it's still an improvement, better than nothing.*"

These challenges were evident in the NCC project. Although Dul-loog was conscientious in respecting and integrating the IPs' culture in their landscape design, much of it did not make it to the final design product. Nonetheless, Dul-loog noted that some features remained until the end.

## OTHER IDEAS NOTED BY THE KEY INFORMANTS

**Property Ownership.** Both key informants shared other ideas that are noteworthy to mention. Alcazaren was relieved with the lack of property ownership problems for the Iloilo Esplanade. He compared the Iloilo River to Pasig River. According to Alcazaren, much like the rivers of most LGUs, the banks of the Pasig River were flanked with large buildings and major manufacturing plants. This presented legal and logistical difficulties in maintaining its cleanliness and ecological integrity. In comparison, The Iloilo LGU owned most of the lots along the Iloilo River and was able to keep it clean and ecologically healthy.

**Heritage Policies.** Alcazaren mentioned it also helped that many of Iloilo's heritage laws were prescriptive. He elaborated that it is an important job for LGUs to "*pass ordinances over and above what it already must entice building owners to conserve their buildings and spaces and [to] direct development.*"

**BGI Reference Materials.** Dul-loog underscored the importance of reference materials such as books to inform the design process. For NCC, he consulted the Singapore-published book "River. Space. Design.", which showed how LGUs from foreign countries developed or redesigned their river systems and river edges. He added that a handbook on blue-green infrastructure in the Philippine context would have helped them in the NCC landscape design process.

# STRATEGIES

## OVERVIEW

There are myriad ways to implement BGI in the Philippines. The first step is overcoming the initial prejudices in choosing BGI interventions over traditional gray infrastructure as a practical alternative to answer the severe issues that the country faces amid changing times.

This section lists BGI implementation tactics that have been proven to work in a variety of public and private greening infrastructure projects around the world. These strategies are organized based on the many facets of BGI implementation that have been encountered in past applications, as well as the lessons learnt from those experiences.

- EXISTING POLICIES ON BGI
  This segment lists down laws, plans, and policies that are already in place favoring the implementation of blue-green interventions in the country.

- JUMPSTARTING BGI INITIATIVES
  This segment illustrates strategies to promote BGI for encouraging BGI consideration and implementation, as well as ensuring the long-term viability of such undertakings.

- MAINSTREAMING BGI
  This segment builds on the preceding topic by demonstrating how BGI can be adapted into the mainstream decision-making and solutions.

- SUSTAINING BGI
  This segment addresses maintenance and challenges that shed light on effective BGI execution in the long term.

- FINANCING BGI
  This segment deals with measures to raise the profile of BGI by providing financial incentives that support green infrastructure development among stakeholders and interested entities.

- DESIGNING BGI
  This segment enumerates considerations for designing selected physical landscape strategies highlighted in this guide.

The strategies here are generalized to account for flexibility of application for a variety of settings.

While these recommendations aim to guide towards best practices in BGI, professionals and decision-makers are expected to base their designs on applicable laws and regulations within their professional scope. These were also developed to supplement current greening laws, rules, ordinances, and development procedures to further the BGI goal.

## EXISTING POLICIES ON BGI

**Policy Strategies at the National Scale**. The following are existing policy strategies applicable at the national scale.

*EO 263*. Adopting community-based forest management as a national strategy for ensuring the sustainable development of the country's forest land resources and putting in place mechanisms to achieve it. Its purpose is to entrust responsibility to the community stakeholders. Forest rehabilitation. Protection. Conservation.

Integrate and unify all people-oriented forestry programs of the government. Shall grant rights to local communities and indigenous peoples to protect, rehabilitate, develop, and manage forestlands and coastal resources. Department of Natural Resources and Environment lays down rules and regulations for implementation.

*RA 826*. An Act Creating the Commission on Parks and Wildlife, Defining its Powers, Functions and Duties. Created to promote effectual planning, development, maintenance, and conservation of national parks, monuments, and wildlife in said parks, of game and fish, and of provincial, city and municipal public parks, to provide for the enjoyment of the same, and to carry out the provisions of this Act.

The Commission administers its duties to promote, conserve, maintain, and regulate the use of national parks, national monuments, and wildlife in said parks, of game and fish, game refuges, bird sanctuaries, and game farm and to aid, and cooperate with, the provinces, chartered cities, municipalities and municipal districts in the establishment and conservation of provincial, city, municipal and municipal district parks, and monuments.

According to this Act, Parks and Wildlife are identified as national parks and national monuments. This includes the wildlife in them. Of game and fish, game refuges, bird sanctuaries, and game farm.

According to this Act, Parks and Wildlife fundamental purpose of the said parks are to conserve the scenery and the natural and historic objects and the wildlife therein, including bird, fishes, mammals, and other animals and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the benefit and enjoyment of future generations.

The Commission shall have power to (1) adopt rules and regulations for the administration of this Act, and the transaction of the business of the Commission; (2) Make expenditures for the care, supervision, improvement, development, extension and maintenance of all parks, parkways, and monuments under the control of the Commission and for the protection and conservation of wildlife and game fish, game refuges, bird sanctuaries and game farms; (3) Make rules and regulations governing the proper use and protection of park areas, game refuges, bird sanctuaries and game farms and to protect property and preserve the peace therein; and (4) Cooperate with the local government for the purpose of securing improvement, development, or maintenance of lands which are designated as parks or pleasure grounds and to secure agreements between the local governments for the accomplishment of the purposes of this Act.

The Commission can act on the behalf of the national, provincial, and municipal governments, as well as the municipal district government. It may acquire lands suitable for park purposes, the means of acquisition of which include gift, donation, contribution or otherwise. They may receive and accept devices bequests and other gifts or beneficial transfers of property, money, and other objects.

The purpose of this acquisitional power is for improvement or ornamentation of any national, provincial, city, municipal or municipal district park, pleasure ground, parkway, avenue, or road, for the establishment in said park or pleasure ground of zoological or other gardens,

collections of natural history, monuments or works of arts, and for conservation of wildlife, game birds or animals.

*RA 10066*. Law that provides for the protection and preservation of the nation's cultural heritage or The National Cultural Heritage Act of 2009. It fulfills Sections 14-17 of the Philippine Constitution of 1987, which require the government to conserve and develop the nation's resources. World Heritage Sites. — The appropriate cultural agency shall closely collaborate with the United Nations Educational Scientific and Cultural Organization (UNESCO) National Commission of the Philippines in ensuring the conservation and management of world heritage sites, of cultural and mixed sites category, in the Philippines.

Section 32. Institutional Linkages of the National Cultural Agencies. — The cultural agencies and other national government agencies, as listed below, shall consult, coordinate and work closely with the Commission in the implementation of their respective programs/projects in the context of this Act. Furthermore, the Commission may link up with other agencies and institutions, as it may deem appropriate, as a way of dealing with conservation in a holistic manner:

The Department of Tourism and its attached agencies which shall be responsible for cultural education among tourism services, and protection of cultural properties supplemental to the jurisdiction of the cultural agencies as defined in this Act. The implementation and creation of a tourism master plan shall be consistent with this Act;

The Intramuros Administration which shall be responsible for the restoration and administration of the development in Intramuros;

The National Parks Development Committee as an attached agency of the Department of Tourism which shall be responsible in supervising the development (beautification, preservation and maintenance) of the Quezon Memorial, Fort Santiago, Luneta, Paco Park, Pook ni Maria Makiling and other national parks and satellite projects;

The Department of Education which shall be responsible in instituting the governance of basic education act, and the conservation and restoration of its built heritage such as the significant Gabaldon school buildings as determined by the National Historical institute;

The Department of Public Works and Highways which shall be responsible in undertaking major infrastructure projects specifically in the planning, design, construction, and maintenance of national roads and bridges as they impact on heritage structures or aspects of heritage conservation;

The National Commission on Indigenous Peoples, in behalf of the country's indigenous cultural communities, which shall coordinate with the national agencies on matters pertaining to cultural properties under its jurisdiction;

The Department of Environment and Natural Resources which shall be responsible for the establishment and management of the National Integrated Protected Areas System and the conservation of wildlife resources, including cave and cave resources and which shall coordinate with the National Commission on Indigenous Peoples, the conservation of natural resources that are cultural sanctuaries of indigenous peoples;

The Department of the Interior and Local Government which shall coordinate with the national cultural agencies on matters pertaining to cultural properties under its jurisdiction, and ensure that the provisions of this Act is properly executed by the local government unit;

The Office on Muslim Affairs which shall coordinate with the national cultural agencies on matters pertaining to cultural properties under its jurisdiction;

The UNESCO National Commission of the Philippines which shall be responsible for providing the liaison between the cultural agencies of the Philippines and the UNESCO as well as assist the national cultural agencies in implementing the agreements and conventions adopted by the UNESCO of which the Philippines has ratified or is in the process of ratification;

The Housing and Land Use Regulatory Board which shall coordinate with the local government units and the Commission on matters pertaining to the establishment and maintenance of heritage zones;

The Autonomous Region in Muslim Mindanao and the Cordillera Administrative Region which shall coordinate with the national cultural agencies on matters pertaining to cultural properties under their respective jurisdictions;

Article IX: Cultural Property Incentives Program. Section 36. National Heritage Resource Assistance Program. – The Commission may provide financial assistance in the form of a grant to historic, archaeological, architectural, artistic organizations for conservation or research on cultural property. No grant made pursuant to this Act shall be treated as taxable income.

*RA 7586*. Shall encompass outstandingly remarkable areas and biologically important public lands that are habitats of rare and endangered species of plants and animals, biogeographic zones and related ecosystems, whether terrestrial, wetland or marine, all of which shall be designated as "protected areas". These include strict nature reserves, natural parks, natural monuments, wildlife sanctuaries, protected landscapes and seascapes, resource reserve, natural biotic areas and other categories established by law, conventions, or international agreements which the Philippine Government is a signatory.

*PD 953*. Requiring the planting of trees in certain places and penalizing unauthorized cutting, destruction, damaging, and injuring of certain trees, plants, and vegetation.

*PD 957*. Section 1. Design Standards for Subdivision. Residential subdivision projects shall conform with the following minimum design standards, applicable local government units' (LGU) zoning ordinances as well as pertinent provisions of the National Building Code if project is with housing component:

Site Criteria. Location. Conformity with Zoning Ordinance/Comprehensive Land Use Plan. Subdivision projects shall be in residential zones or other areas appropriate for residential uses. If there is no Zoning Ordinance or approved Comprehensive Land Use Plan, the dominant land use principle and site suitability factors cited herein shall be used in determining suitability of a project.

Open spaces shall conform to the provisions of P.D. 1216 and its implementing rules and shall include the following:

Streets - adequate and safe means of vehicular and pedestrian circulation and easements for utilities and planting strips, shall be provided.

Walks - paved walks shall be provided to the living units from streets, parking spaces and from living units to play areas

Parks and playground - suitable recreational area(s) shall be allocated within the subdivision. Where applicable, a hierarchy of such recreational areas may be provided for, such that, a strategically located main park area is supplemented or complemented by one or more smaller pocket(s) or areas for recreational use. These areas must be accessible to living units and free from any form of hazard or risk_ Said parks and playgrounds shall be cleared and free from any debris. Parks and playgrounds as much as possible shall be at street level.

Facilities and Amenities. Areas required for subdivision facilities and amenities shall be judiciously allocated in accordance with the provisions herein specified.

Site Preservation. Slope. The finished grade shall have a desired slope to allow rainwater to be channeled into street drains. Where cut and fill is necessary, an appropriate grade shall be attained to prevent any depression in the area. Grading and ditching shall be executed in a manner that will prevent erosion or flooding of adjoining properties.

Preservation of Site Assets. Suitable trees with a caliper diameter of 200 millimeters or more, shrubs and desirable ground cover per Department of Environment and Natural Resources (DENR) rules shall be preserved. Where a good quality topsoil exists in the site, it shall be banked and shall be preserved for finishing grades of yards, playgrounds, parks and garden area.

Ground Cover. Grass, shrubs, plants and other landscaping materials used for ground cover shall be of a variety appropriate for its intended use and location. They shall be planted so as to allow well-tended cover of the area.

Circulation. Depending on the classification of roads adjacent to the subdivision and the size of the project site, road network should result into a hierarchy of functions and should define and serve the subdivision as one integrated unit. Roads complemented with pathwalks within the subdivision must be so aligned to facilitate movement and to link the subdivision to the nearest major transportation route and/or adjacent property. Whenever there are existing roads within the project site which shall be made part of the subdivision plan, these shall be improved in accordance with the standards set forth herein.

Streets should conform to the contours of the land as far as practicable. Where a proposed project adjoins a developed property, roads within the said project shall be connected, integrated, or aligned with existing ones. Where a proposed project adjoins undeveloped property, a provision for future connection shall be mandatory.

Design Parameters. Land Allocation. Parks/Playgrounds. Allocation of area for parks and playgrounds shall be mandatory for projects one (1) hectare or more and shall be deemed non-buildable area. The same shall be strategically located within the subdivision project. Area allocated for parks and playgrounds shall in no case be less than 100 square meters.

*PD 1096*. PD 1096 - RA 6541: National Building Code of the Philippines - An Act to Ordain And Institute A National Building Code Of The Philippine. Streets are defined as "any thoroughfare or public space which has been dedicated or deeded to the public for public use," according to the National Building Code. The scope of Republic Act No. 6541 includes design, location, siting, construction, alteration, repair, conversion, use, occupancy, maintenance, moving, and demolition of both private and public buildings.

*PD 1559*. PD 705 Revised Forestry Code of the Philippines as amended by PD 1559, PD 865, PD 1775, BP 701, BP 83, RA 7161, EO 277 and Official Gazette No. 31.

Whereas Clauses (Reasons for the Law)•There is an urgent need for proper classification, management and utilization of the lands of the public domain to maximize their productivity to meet the demands of our increasing population;•To achieve the above purpose, it is necessary to reassess the multiple uses of forest lands and resources before allowing any utilization thereof to optimize the benefits that can be derived therefrom;•It is imperative to place emphasis not only on the utilization thereof but more so on the protection, rehabilitation and development of forest lands, in order to ensure the continuity of their productive condition;

Policies. The multiple uses of forest lands shall be oriented to the development and progress requirements of the country, the advancement of science and technology, and the public welfare; Land classification and survey shall be systemized and hastened; The establishment of wood-processing plants shall be encouraged and rationalized; and The protection, development and rehabilitation of forest lands shall be emphasized so as to ensure their continuity in productive condition.

Definitions. Public forest is the mass of lands of the public domain which has not been the subject of the present system of classification for the determination of which lands are needed for forest purposes and which are not.

*PD 1216*. "Open space," refers to "an area reserved exclusively for parks, playgrounds, recreational uses, schools, roads, places of worship, hospitals, health centers, barangay centers and other similar facilities and amenities".

Subdivisions and developments with at least one hectare (and up) should have at least 30% open space, according to PD 1216 Section 31. In this 30%, standards for parks, playgrounds, and areas for recreational use are also specified. These reserved public lands are to be non-alienable (cannot be bought or given titles) and non-buildable. 9% of gross area for high density or social housing, 7% of gross area for medium-density or economic housing, and 3.5% of gross area low-density or open market housing. The same section of PD1216 also provides for adequate roads, alleys, and sidewalks, and specifies that subdivision project should have tree planting on designated areas.

*BP 220*. Parks and playgrounds are listed as basic needs of human settlements.

*1987 Constitution*. (Section 2) All lands of the public domain, waters, minerals, coal, petroleum, and other mineral oils, all forces of potential energy, fisheries, forests or timber, wildlife, flora and fauna, and other natural resources are owned by the State. (Section 3) Lands of the public domain are classified into agricultural, forest or timber, mineral lands and national parks.

*RA 386, Article 420*. Those intended for public use, such as roads, canals, rivers, torrents, ports and bridges constructed by the State, banks, shores, roadsteads, and others of similar character; and those which belong to the State, without being for public use, and are intended for some public service or for the development of the national wealth.

*RA 6541, Annex: Definition of Terms*. Streets are defined as "any thoroughfare or public space which has been dedicated or deeded to the public for public use".

**Policy Strategies at the Local Scale**. The following are existing policy strategies applicable at the local scale.

*RA 826*. An Act Creating the Commission on Parks and Wildlife, Defining its Powers, Functions and Duties. Section 10. Management of local parks—Rules.— The Board of Park Commissioners shall have the management and control of public parks, pleasure grounds and parkways of the province, city, municipality, or municipal district wherein it is appointed. It shall establish necessary rules and regulations not in conflict with law or the ordinances of the city, municipality or municipal district for the proper supervision and use of such parks, pleasure grounds and parkways and shall have such additional powers relating thereto as may be prescribed by resolution of the provincial board or ordinance by the city, municipal, or municipal district council. The provincial board, city, municipal, or municipal district council concerned shall, by resolution or ordinance, provide for the enforcement of the rules and regulations promulgated by the Board of Park Commissioners. The Board may appoint a park caretaker, who shall be a practical landscape gardener, and who shall, under the direction of the Board, have active charge, control and direction of all parks, pleasure grounds or parkways under the control of said Board, and perform such other duties as may be required by the Board.

*RA 7160*. For Barangay: Agricultural support services which include planting materials distribution system and operation of farm produce collection and buying stations; Health and social welfare services which include maintenance of barangay health center and day-care center. Services and facilities related to general hygiene and sanitation, beautification, and solid waste

collection; Maintenance of *katarungang pambarangay*; Maintenance of barangay roads and bridges and water supply systems; Infrastructure facilities such as multi-purpose hall, multipurpose pavement, plaza, sports center, and other similar facilities; Information and reading center; and satellite or public market, where viable.

For a Municipality: Extension and on-site research services and facilities related to agriculture and fishery activities which include dispersal of livestock and poultry, fingerlings, and other seedling materials for aquaculture; palay, corn, and vegetable seed farms; medicinal plant gardens; fruit tree, coconut, and other kinds of seedling nurseries; demonstration farms; quality control of copra and improvement and development of local distribution channels, preferably through cooperatives; interbarangay irrigation system; water and soil resource utilization and conservation projects; and enforcement of fishery laws in municipal waters including the conservation of mangroves;

Pursuant to national policies and subject to supervision, control and review of the DENR, implementation of community-based forestry projects which include integrated social forestry programs and similar projects; management and control of communal forests with an area not exceeding fifty (50) square kilometers; establishment of tree parks, greenbelts, and similar forest development projects;

Information services which include investments and job placement information systems, tax and marketing information systems, and maintenance of a public library; Solid waste disposal system or environmental management system and services or facilities related to general hygiene and sanitation; Municipal buildings, cultural centers, public parks including freedom parks, playgrounds, and other sports facilities and equipment, and other similar facilities; Infrastructure facilities intended primarily to service the needs of the residents of the municipality and which are funded out of municipal funds including but not limited to, municipal roads and bridges; school buildings and other facilities for public elementary and secondary schools; clinics, health centers and other health facilities necessary to carry out health services; communal irrigation, small water impounding projects and other similar projects; fish ports; artesian wells, spring development, rainwater collectors and water supply systems; seawalls, dikes, drainage and sewerage, and flood control; traffic signals and road signs; and similar facilities; Sites for police and fire stations and substations and municipal jail;

**Policy Strategies at the Sectoral Scale**. The following are existing policy strategies applicable at the sectoral scale.

*RA 826*. An Act Creating the Commission on Parks and Wildlife, Defining its Powers, Functions and Duties. Section 7. Provincial, city and municipal parks. — Any province, city, municipality, or municipal district may acquire, establish and maintain public parks, pleasure grounds and parkways within the boundaries of said province, city, municipality or municipal district. Lands which may be required for any such of purposes may be set aside by such province, city, municipality, or municipal district and devoted to such purposes, out of any lands or parcels of land owned or possessed by any such province, city, municipality or municipal district; or said lands may be acquired by gift or purchase, in the manner provided by law: Provided, That no lands, the purchase price of which exceeds one thousand pesos, shall be acquired by purchase by a province, city, municipality, or municipal district for any of such purposes without the previous approval of the President of the Philippines.

Any province, city, municipality, or municipal district establishing public parks, pleasure grounds or parkways under the provisions of this Act shall, by its duly constituted authority, have full power to cultivate, plant and otherwise improve the same; and shall enact resolutions or ordinances for the proper administration, maintenance and use thereof.

Section 8. Cities and towns may unite in establishing parks. — Any two or more cities, municipalities or municipal districts which are contiguous or adjacent may unite in acquiring,

establishing and maintaining public parks, pleasure grounds or parkways of their common benefit upon such terms and conditions as may be mutually agreed upon by ordinance.

*RA 7160*. Water bodies are owned by the state, and yes, they are also public spaces. The Local Government Code (RA 7160) section 131 defines 'municipal waters,' as such:

> *"…includes not only streams, lakes, and tidal waters within the municipality, not being the subject of private ownership and not comprised within the national parks, public forest, timber lands, forest reserves or fishery reserves, but also marine waters included between two lines drawn perpendicularly to the general coastline from points where the boundary lines of the municipality or city touch the sea at low tide and a third line parallel with the general coastline and fifteen (15) kilometers from it. Where two (2) municipalities are so situated on the opposite shores that there is less than fifteen (15) kilometers of marine waters between them, the third line shall be equally distant from opposite shores of their respective municipalities."*

For a province: agricultural extension and on-site research services and facilities which include the prevention and control of plant and animal pests and diseases; dairy farms, livestock markets, animal breeding stations, and artificial insemination centers; and assistance in the organization of farmers and fishermen's cooperatives, and other collective organizations, as well as the transfer of appropriate technology.

Industrial research and development services, as well as the transfer of appropriate technology.

Pursuant to national policies and subject to supervision, control and review of the DENR, enforcement of forestry laws limited to community-based forestry projects, pollution control law, small-scale mining law, and other laws on the protection of the environment; and mini-hydroelectric projects for local purposes.

Subject to the provisions of Title Five, Book I of this Code, health services which include hospitals and other tertiary health services.

Infrastructure facilities intended to service the needs of the residence of the province and which are funded out of provincial funds including, but not limited to, provincial roads and bridges; inter-municipal waterworks, drainage and sewerage, flood control, and irrigation systems; reclamation projects; and similar facilities.

Tourism development and promotion programs.

For a city: All the services and facilities of the municipality and province, and in addition thereto, the following: adequate communication and transportation facilities.

## JUMPSTARTING BGI INITIATIVES

Embracing green infrastructure eligibilities can provide communities with significant environmental, economic, and social benefits. The difficulty lies in translating eligibilities to actual infrastructure. Communities are sometimes reluctant to pursue green infrastructure solutions due to a lack of familiarity, inability to secure a repayment source, or other logistical barriers.

**Marketing.** Create a BGI planning guide from which communities can develop site specific strategies that would help meet their community goals. Hold workshops that can lead to development of promotional materials aimed at the wider public. Host webinars for communities to ask questions about programs. Visit communities to identify potential project sites.

**Technical Assistance.** Communities may be receptive to BGI, yet reluctant to commit if unfamiliar with planning or maintenance requirements. State programs can mitigate this through offering technical assistance to help communities conduct a thorough alternatives analysis to identify appropriate technology, to develop a project scope, and to create an operations and maintenance plan. Can also help identify potential revenue stream, since some green infrastructure projects do not have revenue.

**Partnerships.** LGUs can partner with relevant organizations to reach more interested stakeholders/developers. Advantage of having close networks in place. Utilize existing relationships between communities and state and local agencies which may help facilitate green infrastructure funding opportunities.

## MAINSTREAMING BGI

BGI projects are not inherently more complex than more conventional infrastructure projects.

**Institutionalize BGI as Standard in Urban Planning.** An integrated and interdisciplinary approach to BGI is observed to surely come about through cooperation and collaboration agencies and disciplines. The need for cross-agency cooperation adds complexity to the process of BGI planning and implementation and can lead to delays and increase project costs. Institutionalization of appropriate regulations and standards reduce transaction costs and support the creation of new paths of development. The need for institutionalized standards for BGI is crucial for project success if the inter- and intra-agency dynamics are dominated by individual personalities in the present.

Support from an appropriate regulatory framework can go a long way towards simplifying the process for BGI. Formal institutional framework for BGI projects frees the viability of projects from personal and agency politics.

Establish Standards and Routines. Once knowledge base and experience are built through a handful of pilots BGI projects, local decision-makers and experts should create a set of standards to facilitate future BGI implementation. Formal institutional framework for BGI projects frees the viability of projects from personal and agency politics. It can help to initiate changes in well-established habits.

Key Actions: Step 1. Document acquired knowledge and experience in handbooks and guidelines. This documentation supports the transfer of experience from a single project to future projects and enhances the efficiency and effectiveness of BGI implementation. Step 2. Where possible, lessons learned should be communicated to be applicable to different project scales. Step 3. Once this documentation is in place, it should be followed by implementation of effective, enforceable, and sanctionable BGI guidelines and regulations in the urban planning processes like e.g., drainage regulations; policies for land ownership and land use; requirements for rainwater inflows and outflows.

**Vocabulary and Communication.** Stakeholders frequently mentioned a lack of consistent language and terminology which makes it difficult to communicate ideas and across the BGI value chain. As a result of the confusion and lack of alignment between the goals of researchers and actioners, it is difficult to open the conversation between stakeholders at the onset. A common vocabulary for BGI, as well as an understanding of the practicalities involved in BGI implementation, is thus a critical requirement.

**Standardization.** Setting standards for the construction of BGI and increasing awareness of the topic is widely perceived as necessary by stakeholders. To enhance accountability, the integration of public concerns in the process of developing standards should be considered.

**Links to Policy**. BGI needs to be underpinned by strong policy links at regional and local levels. This will assist in ensuring an improved cross sectoral implementation of BGI in addressing environmental and societal challenges such as water, health, biodiversity, and climate change. This can in part be achieved by emphasizing the economic benefits of BGI and providing the 'business case' to decision makers. Regulations can be a key driver for the implementation of BGI, as exemplified by the mandatory green roof policy in Antwerp. Aligning BGI implementation with national or supranational policies is identified as a major factor of success. For example, the European Union's biodiversity strategy provides promising opportunities for BGI.

## SUSTAINING BGI

**Maintenance.** In the future, incentives must be provided for property owners to plant trees through government schemes to contribute to the increase of tree canopies in target areas. This new planting must complement the existing landscape conditions of the area and avoid damage ecological or historical features. Note that not all areas can support wide-scale tree planting, and so planting strategies must depend on context.

**Continuing Education and Community Involvement and Development.** To ensure continuity and visibility of employing BGI initiatives to the mainstream.

Spur volunteerism through fully funded projects for BGI maintenance. These projects must provide guidance, training, equipment, materials, and allowance/honorarium for volunteers.

Must hire project staff that would provide training to volunteers.

These projects can also be open not just to community volunteers but also farmers, students, gardeners, and appropriate local authorities.

Projects must utilize locally bought supplies (e.g., native plants from local suppliers, local equipment, etc.) to support small local business and minimize risk to the area due to introduced pests/diseases.

Introduce events, like planting activities, to make community members aware of their environment.

Increased awareness encourages community members to remove litter and fly-tipped green wastes.

Local gardeners are made aware of the negative impact of dumping waste into sensitive natural habitats. Introduces disease. Use of toxic chemicals. Introduce invasive species.

Community benefit. Community volunteers and school pupils/students can learn survey techniques. Help them assess the condition, biodiversity, and connectivity of the areas' BGI elements. Community benefit by having project mentors work with members of the community who are less fortunate. Community benefit include introducing conservation into the local level. Inspiring replication through creating new community groups that provide free training to interested volunteers.

Incite cooperation between landowners, conservation groups, and volunteer groups

**Funding, Management, and Maintenance.** BGI methods require maintenance and may need to be identified. Through local government funding and through other means. A budgetary shortfall may limit the availability of resources for new projects derived from government funds. Neighborhood groups and organizations attempting to initiate BGI interventions in their locality may need to work with local officials to obtain intergovernmental grant funds or charitable sources, until BGI strategies are integrated into the annual budget once it is institutionalized.

## FINANCING BGI

**Financing Green Infrastructure.** Cities play a critical role in planning and investing in urban infrastructure. In many cases, local governments have authority over the selection of infrastructure projects made at the municipal level. Therefore, they exercise influence over the nature of infrastructure renewal and expansion and can promote greener and more sustainable urban centers.

Their leadership role extends to the kinds of investment mechanism selected to finance, for example, improvements in the transportation, building, waste and water and, to a lesser extent, energy sector. Because cities have revenue sources that are tied to many aspects of these sectors, their design can stimulate or dissuade the development of greener and more sustainable cities.

Currently, much of the Philippines' investment in infrastructure is being carried out through public funding and public– private partnership (PPP) ventures. However, public funding is not sufficient to meet the growing demand for green infrastructure; new channels will be necessary to mobilize private capital. Further, existing funding commitments made by the government may be challenged by the current COVID-19 pandemic and ensuing economic crisis, so looking to the market for additional investment will be key to growing green pipelines.

The World Bank has developed a disaster risk-financing and insurance (DRFI) framework for understanding and improving the financial resilience of states against disasters. The DRFI framework promotes a dual approach to increasing overall financial resilience based on financial disaster risk assessment and modeling (figure 6.1, see also Cummins and Mahul 2010). This approach includes the following: (1) sovereign disaster risk financing, which entails identification and assessment of the government's contingent liabilities associated with natural hazards and financial strategies to increase their financial response capacity in the aftermath of a disaster while protecting their long-term fiscal balance, and (2) catastrophe risk market development, which increases the transfer of public and private risks to the insurance sector.

**Benefits Estimation Tool.** For valuing the benefits of blue-green infrastructure, the Benefits Estimation Tool (BEST) provides a structured approach to help identify and quantify the financial, social and environmental benefits of sustainable drainage systems (SuDS) and natural flood management (NFM). The updated tool is based on the latest evidence and can be used to support the cost–benefit assessments needed to secure investment in new blue-green infrastructure. It will help risk management authorities, planners, landscape architects and drainage engineers to understand and measure the benefits of blue-green infrastructure in urban, semi-urban and rural settings. They can also compare blue-green infrastructure to more traditional approaches such as flood walls and piped drainage.

BEST also measures and financially quantifies the multiple benefits of SuDS and NFM approaches beyond reducing flood risk. This can help to identify potential interested partners to collaborate with to provide new schemes and open up funding opportunities.

The tool aims to calculate the benefits of blue-green infrastructure to compare against costs, engage and encourage others to put SuDS and NFM in place, and provide the evidence needed to help encourage the funding of SuDS and NFM projects in partnership.

It can support people who design blue-green infrastructure schemes, as well as risk management authorities that may be asked to fund or approve SuDS/NFM and want to know the benefits over conventional approaches.

**Mobilizing Private Sector Investments.** Public sector financing, however, may not be sufficient to stimulate a paradigm shift. Therefore, the second critical step is to mobilize private sector investments to fill funding gaps for many urban green infrastructure projects. There are

certain conditions that need to be put in place to attract and capture private sector investments. The three main conditions are (1) markets for green urban investment projects, (2) good return on investment, and (3) limited risk.

Financial instruments used by industrialized/medium income cities to attract private finance for green infrastructure. Private sector involvement in urban green infrastructure can take the form of public-private partnerships (PPPs), in which the long-term risk is transferred to the private sector. Through an alternative instrument, tax increment financing, future tax revenues are used to attract private finance. Real estate developers may also pay for the infrastructure that is needed to connect their new development to existing infrastructure in the form of development charges (impact fees) and value capture (taxes that capture the value increases of real estate due to new infrastructure development nearby). Finally, loans, bonds and carbon finance are instruments used to attract private finance in well-functioning capital markets.

**Set-Asides.** Government can consider prioritizing setting aside funding to incentivize green infrastructure as loan to potential stakeholders. Can be offered at a reduced interest rate as an incentive to potential stakeholders. Can have flexible payment structure to make BGI projects more affordable. Additional subsidization to target assistance to BGI projects.

**Co-funding.** Government can co-fund with other funding sources/grant giving bodies. Especially useful for large projects. Through partial funding, government can use the same funding level to assist a greater number of eligible projects.

**Sponsorship.** Type of lending that pairs a traditional publicly owned treatment works project with a non-traditional one, like a BGI project. Municipalities can receive a loan with reduced interest rate as compensation for undertaking a BGI project thus allowing municipalities to address pressing watershed restoration or protection priorities without placing a repayment responsibility on green infrastructure projects. Arrangement works best when the cost of the combined project is equal to or less than the cost of a stand-alone POTW project when financed at normal interest rates.

**Conduit Lending.** Include pass-through loans to credit intermediaries and linked deposit loans through commercial banks. Both facilitate lending to small, non-traditional projects and are excellent tools for funding green infrastructure projects. A useful strategy for funding green infrastructure on a small scale (e.g., rain barrels at private residences and certain agricultural best management practices). With conduit lending it is the government agency or bank that must secure a source of repayment. Additionally, some smaller borrowers such as homeowners may be more comfortable working with their local banks or local governments.

**Guaranties.** A standalone grant/program can establish a loan guaranty program to support borrowing for green infrastructure projects. Guaranties provide additional security for local debt and allow for reduced interest rates. This is done by transferring the credit risk from private investors, who purchase bonds from local governments to this program. Due to having generally very high credit ratings, local governments would be able to borrow at the most favorable market rates available. Given the relative novelty and accompanying uncertainties of many green infrastructure projects in terms of cost, performance, and repayment streams, guaranties seem poised to play an important role in allocating credit resources to these projects.

**Tapping New Finance Sources.** Carbon finance should be more accessible to cities. Cities and central governments can work together to make better use of carbon-offsetting programs (e.g., the Clean Development Mechanism and Joint Implementation) and to ensure that these (and other) resources may come directly to cities. One of the conditions of carbon finance should be use of a harmonized emission inventory for cities.

Infrastructure needs related to new development should be internalized in the financing of development projects. The costs of sprawl, for example, may be recovered from developers

through development charges or other financial contributions. In a similar fashion, new developments should also, where appropriate, incorporate the cost of investment in alternative water sources.

National-local co-operation is essential to developing access to new forms of green finance. There are a number of potential instruments for tapping private finance in support of urban greening and aligning private investment with policy priorities. These include private-public partnerships, green bonds and green infrastructure banks. However, they each raise potential problems of insufficient size, moral hazard and opportunism. Cities thus need to co-operate with one another and with central governments to build capacity and ensure that they possess the requisite financial, technical and legal expertise, as well as sufficient bargaining power when negotiating private-sector financing

**Green Financing Guide.** Steps: (1) Develop green asset strategy and process; (2) determine appropriate funding sources; (3) deal structuring; (4) debt origination; and (5) post-issuance reporting.

**Funding Sources in the Philippines.** Private banks in the Philippines have led on green finance by issuing of green and sustainability bonds to fund and refinance green assets. To date, the Philippine banks that have issued green bonds are the Bank of the Philippine Islands (BPI), RCBC, BDO Unibank, and China Banking Group. Many banks are also providing green loans and other tools for developing green infrastructure and renewable energy. For instance, the Sustainable Energy Finance (SEF) program, pioneered by BPI, provides access to capital and technical support for renewable project owners. This program has successfully deployed private renewable projects in the Philippines. The SEF model has been replicated by other banks such as BDO Unibank. Other banks, such as Development Bank of the Philippines (DBP) has three initiatives for financing green projects and a sustainable bond program.

In terms of green funds, there is the People's Survival Fund, a domestic initiative, led by the Climate Change Commission (CCC), is the People's Survival Fund (PSF), which was created as an annual fund intended for local government units and accredited local/community organizations to implement climate change adaptation projects that will better equip vulnerable communities to deal with the impacts of climate change.

The Philippine government programmed at least PHP1 billion into the fund, sourced from the national budget, which may be augmented by mobilizing funding sources such as counterpart local government units, the private sector, and individuals who support adaptation initiatives. The PSF is intended for activities including water resources management, land management, and agriculture and fisheries, among others, and serves as guarantee for risk insurance needs for farmers, agricultural workers and other stakeholders.

There is also the ASEAN Catalytic Green Finance Facility (ACGF), established by the ASEAN Infrastructure Fund Ltd. (AIF). The AIF was established in 2012 and is owned by the ASEAN member states and ADB is dedicated to fund infrastructure development needs by mobilizing regional savings, including foreign exchange reserves. The AIF established the ACGF to support governments in Southeast Asia to prepare and finance infrastructure projects that promote environmental sustainability and contribute to climate change goals.

The Philippines is a leader in the ASEAN green bond market. It issued the very first green bond in the region – the AP Renewables' $226 million deal in early 2016.

Banks. Although there has not yet been any issuance of local government green bonds in the Philippines, there may be potential for the future. There is political will, and opportunities for credit enhancement through Philguarantee, a result of the merger and consolidation of five Philippine guarantee programs and agencies, and it could potentially provide credit enhancement to LGUs.

The government could also consider the municipal bond bank model as a tool to increase green local government bonds. These are banks owned and operated by state government agencies, set up with the purpose of aggregating municipal financing needs and lowering the cost of funding. They issue general purpose bonds on the capital markets and redistribute the proceeds to municipalities.

## DESIGNING BGI

The following physical infrastructure landscape strategies will most likely require input from a range of disciplines, including engineering, landscape, urban design, and operations specialists. A concept design will include sufficient information to demonstrate that a concept can be delivered and will include rough sizing to estimate the likely scale of costs and benefits. Design should be specific to local context and seek to maximize the desired benefits and address identified challenges.

**National Scale.** BGI strategies applicable at the national level are the preservation of undisturbed areas, preservation of buffers, reduction of clearing and grading, locating development in less sensitive areas, open space design, and soil restoration.

*Preservation of Undisturbed Areas***.** Delineate and place into permanent conservation undisturbed forests, native vegetated areas, riparian corridors, wetlands, and natural terrain. This helps to preserve a site's natural hydrology and water balance. It can act as a non-structural stormwater feature to promote additional filtration and infiltration and can help to preserve a site's natural character, habitat, and aesthetic appeal. It has also been shown to increase property values for adjacent parcels, and it can reduce structural stormwater management storage requirement and may be used in runoff reduction calculations.

Preserved conservation areas may limit the development potential of a site. With clustering and other development incentives, development yield can be maintained. They may harbor nuisance wildlife, vegetation, and insects and may present safety hazards. Once established, natural conservation areas must be protected during construction and managed after occupancy by a responsible party able to maintain the areas in a natural state in perpetuity. Proper management and maintenance will address these nuisance and safety issues. One must also ensure that conservation areas and native vegetation are protected in an undisturbed state through the design, construction, and occupancy stages. For such, check with the municipality to determine if there are local laws and ordinances that regulate wetlands, stream buffers, forests or habitat protection.

*Preservation of Buffers***.** Define, delineate, and preserve naturally vegetated buffers along perennial streams, rivers, shorelines, and wetlands. Riparian buffers treat stormwater and improve water quality and can be used as nonstructural stormwater infiltration zones. They can keep structures out of the floodplain and provide a right-of-way for large flood events. Help to preserve riparian ecosystems and habitats. Can serve as recreational areas. May be used in runoff reduction calculations if the criteria in this section are met.

Buffers may result in a potential loss of developable land – Regulatory tools or other incentives may be available to protect the interests of property owners. Private landowners may be required to provide public access to privately held stream buffers – Effective buffers can be maintained in private ownership through deed restrictions and conservation easements.

Nuisance wildlife, vegetation, and insects will be present due to the natural buffer area – Once established, vegetated buffers must be protected during construction and managed after occupancy by a responsible party able to maintain the areas in a natural state in perpetuity; proper management and maintenance will address nuisance issues.

Define the width, identify the target vegetation, and designate methods to preserve the buffer indefinitely. Ensure that buffers and native vegetation are protected throughout planning, design, construction, and occupancy. Consult local planning authority for local wetland and/or stream regulations or guidelines for more stringent minimum buffer width.

*Reduction of Clearing and Grading*. Limit clearing and grading to the minimum amount needed for roads, driveways, foundations, utilities, and stormwater management. Preserves more undisturbed natural areas on a development site. Areas of a site that are conserved in their natural state retain their natural hydrology and do not contribute to construction erosion. Native trees, shrubs and grasses provide natural landscaping, reducing costs and contributing to the overall quality and viability of the environment.

Preserving trees during construction is expensive – Minimizing clearing during construction can reduce earth movement and reduce erosion and sediment control costs. People prefer large lawns – Lots with trees may have a higher value than those without.

Preserved conservation areas may harbor nuisance wildlife, vegetation, and insects and may present safety hazards – Once established, natural conservation areas must be protected during construction and managed after occupancy by a responsible party to maintain the areas in a natural state in perpetuity; proper management and maintenance will address nuisance and safety issues.

Restrict clearing to minimum reqd. for building footprints, construction access, and safety setbacks. Establish limits of disturbance for all development activities. Use site foot-printing to minimize clearing and land disturbance. Avoid mass grading of a site – divide into smaller areas for phased grading. Use conservation design, open-space or "cluster" developments. Consult local planning authority for local clearing and grading regulations.

*Locating Development in Less Sensitive Areas*. Avoid sensitive resource areas such as floodplains, steep slopes, erodible soils, wetlands, mature forests, and critical habitats by locating development to fit the terrain in areas that will create the least impact. Preserving floodplains provides a natural right-of-way and temporary storage for large flood events; keeps people and structures out of harm's way and helps to preserve riparian ecosystems and habitats. Preserving steep slopes and building on flatter areas helps to prevent soil erosion and minimizes stormwater runoff; helps to stabilize hillsides and soils and reduces the need for cut-and-fill and grading. Avoiding development on erodible soils can prevent sedimentation problems and water-quality degradation. Areas with highly permeable soils can be used as nonstructural stormwater infiltration zones. Fitting the design to the terrain and in less sensitive areas helps to preserve the natural hydrology and drainageways of a site; reduces the need for grading and land disturbance and provides a framework for site design and layout.

Costs will be higher for developments due to increased planning and design, localized construction and less developable land – Developments that protect sensitive areas may have higher market value, less liability for potential natural disasters, such as flooding or slope failures and lower construction costs for areas that require less earthwork or difficult terrain, such as steep slopes or wetland areas to work around.

Ensure all development activities do not encroach on, fill or alter designated floodplain and/or wetland areas. Avoid development on steep slope areas and minimize grading and flattening of hills and ridges. Leave wetlands, floodplains, and areas of porous or highly erodible soils as undisturbed conservation areas. Develop roadway patterns to fit the site terrain and locate buildings and impervious surfaces away from steep slopes, drainage ways and floodplains. Locate sites in areas less sensitive to disturbance or have a lower value in terms of hydrologic function.

*Open Space Design*. Use clustering, conservation design or open space design to reduce impervious cover, preserve more open space and protect water resources. Preserves conservation

areas on a development site. Can be used to preserve natural hydrology and drainageways. Can be used to help protect natural conservation areas and other site features. Reduces the need for grading and land disturbance. Reduces infrastructure needs and overall development costs. Allows flexibility to developers to implement creative site designs including better stormwater management practices.

Smaller lot sizes and compact development may be perceived by developers as less marketable – Open space designs can be highly desirable and have economic advantages such as cost savings and higher market appreciation. Lack of speed and certainty in the review process may be of concern – Consult with the local review authority to review requirements; prospective homebuyers may be reluctant to purchase homes due to concerns regarding management of the community open space – Proper methods and implementation of maintenance agreements are available; natural open space reduces maintenance costs and can help keep association fees down.

Cluster developments appear incompatible with adjacent land uses and are equated with increased noise and traffic – Open space design allows preservation of natural areas, using less space for streets, sidewalks, parking lots, and driveways; incorporating buffers into the design can help alleviate incompatibility with other competing land uses streets, sidewalks, parking lots, and driveways; incorporating buffers into the design can help alleviate incompatibility with other competing land uses.

Use a site design which concentrates development and preserves open space and natural areas of the site. Locate the developed portion of the cluster areas in the least sensitive areas of the site. Consult with the municipality to find out whether there is a local law or ordinance for cluster development, open space design, conservation design or flexible subdivisions. Where allowed by the municipality, utilize reduced setbacks and frontages, and narrower right-of way widths to design non-traditional lot layouts within the cluster.

*Soil Restoration*. Restore the original properties and porosity of the soil by deep till and amendment with compost to reduce the generation of runoff and enhance the runoff reduction performance of post construction practices. More marketable buildings and landscapes. Less stormwater runoff, better water quality. Healthier, aesthetically pleasing landscapes. Increased porosity on redevelopment sites where impervious cover is converted to pervious. Achieves performance standards on runoff reduction practices. Decreases runoff volume generated and lowers the demand on runoff control structures. Enhances direct groundwater recharge. Promotes successful long-term revegetation by restoring soil organic matter, permeability, drainage and water holding capacity for healthy root system development of trees, shrubs and deep-rooted ground covers, minimizing lawn chemical requirements, plant drowning during wet periods, and burnout during dry periods

Higher cost due to soil restoration- application of soil de-compaction and enhancement may have additional initial cost; however, they provide benefit in reducing the need for conveyance structures. Space constraints and obstruction for use of equipment - post construction space may limit the ability of some of the de-compaction equipment, however, alternative equipment and sensible planning help overcome this obstacle.

Soil restoration application during periods of relatively low to moderate subsoil moisture through compost. Planting the appropriate ground cover with deep roots to maintain the soil structure.

**Local Scale.** There are several BGI strategies one may apply at the local scale. Provide a location and shape for the space which allows for meaningful and safe recreation and be sufficiently overlooked by active building frontages. Be easily found and accessible by road, cycleway, footpaths, and public transport including by those with disabilities, with pedestrian crossings on roads where appropriate. Make the entrances accessible for all users, of appropriate size and

inviting with a welcoming sign where appropriate. Provide clearly defined boundaries with fences or hedges where needed to ensure safety of users.

Where appropriate provide interest and activities for a wide range of users in particular meeting the needs of elderly and less able users as well as children, young people, and families. Where appropriate provide seats, litter bins and appropriate lighting to ensure safety of users without adversely affecting wildlife.

Provide a range of planting, with appropriate mix of predominantly indigenous species, maintained to a good standard. Promote biodiversity on-site through design, choice of species and management practices. Submit an Open Space Layout and Design statement, to incorporate ecological management measures for approval by the council. Provide a Management Plan with adequate resources identified for on-going management and maintenance.

**Sectoral Scale.** BGI strategies applicable at the sectoral level include vegetated riparian zones, green spaces in floodplains, floodplain wetlands, urban rivers, creeks, and canals, floodable parks and plazas, green streets, retention alleys, cloudburst pipes and roads, green roofs and green walls, and bioswales and bioretention areas. These strategies are to be designed as part of the green infrastructure network in a locality, contributing to local landscape character, connecting with local routes and green corridors for people and wildlife as well as providing multi-functional benefits such as addressing surface water management priorities. Hence, one must provide a location and shape for the space which allows for meaningful and safe recreation and be sufficiently overlooked by active building frontages.

*Vegetated Riparian Zones*. Vegetated riparian zones are lands that are usually along meandering river valleys and with opportunities for ample capability to support diverse vegetation due to its fertile nature, owing to the absorption of nutrients from the constant contact with water and runoff.

Developing vegetated riparian zones entail conserving the character and continuity of the riparian corridor. To achieve this requires keeping several pointers in mind. Redesign of stream or riverfront parks to allow for seasonal and cloudburst flooding. Build capacity for stormwater through retention and detention. Ensure ecological value is maintained through ensuring water cleanliness in the channel. Maintain and enhance the existing character of the river corridor, and in case of ecological degradation or heightened development footprint in the vicinity, identify opportunities for revitalizing habitats especially in the inner half of the zone closest to the water. Retain and revitalize water features and protect the river margin through riverbank stabilization and erosion protection techniques like open gabion cages along the riverbank that provide a porous foundation for tree roots and riparian vegetation and provide habitat niche for various flora and fauna. Ideally, for shallow and steady flow rivers, establish buffer zone with grasses and understory plants at least 20 meters from the top of the bank to achieve effective pollutant and nutrient stripping, and the wider the buffer zone is the more effective it is. Buffer zones are also more effective when the flow is shallow and steady.

Fig. X.X. Vegetated riparian zones.

*Green Spaces in Floodplains*. A hazard mitigation tool due to positive outcomes that facilitate more effective reduction of flood impact in urban areas. Can create multifunctional public space beside the water offering direct contact at various levels. Opening new sightlines, they can achieve striking connections between the urban surroundings and the river.

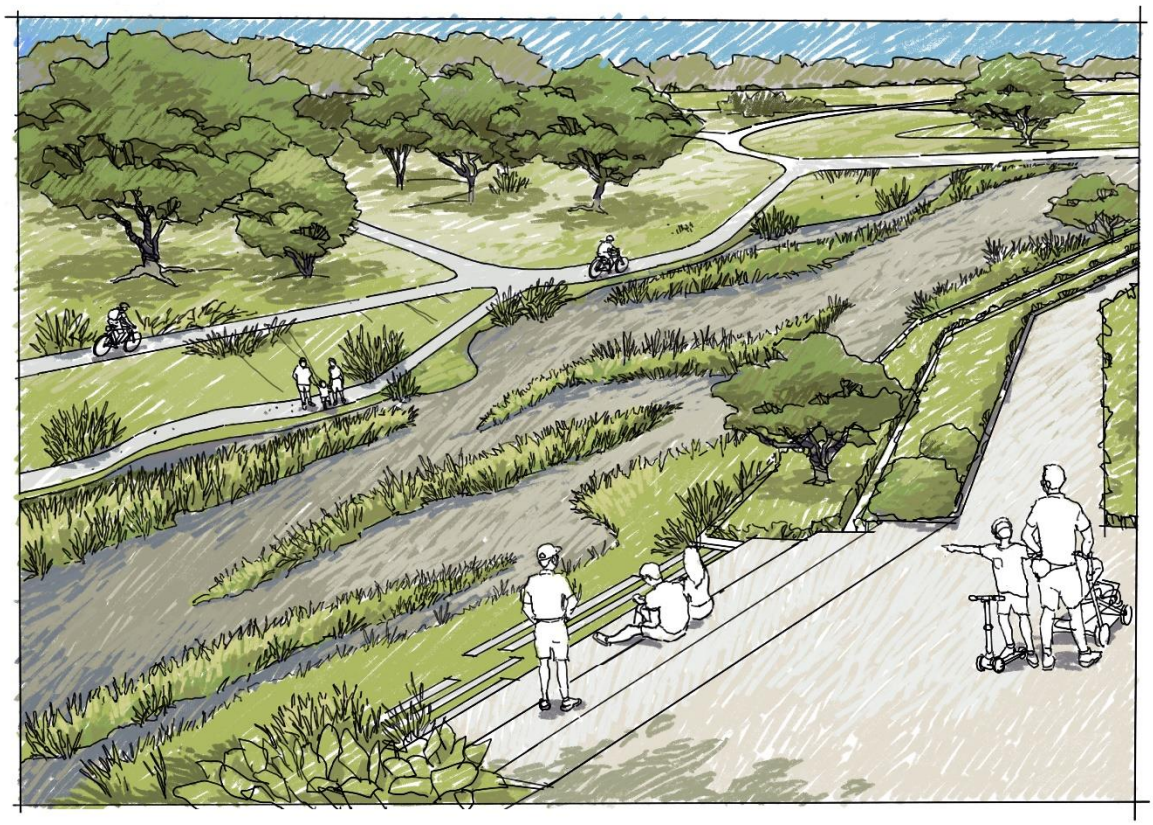

Fig. X.X. Green spaces in floodplains.

*Floodplain Wetlands*. Serve as an interstitial environment between the water and the river edge/shore. Using native tree species to provide shade and habitat. Wetlands planted with native sedges provide habitat for aquatic and terrestrial fauna that wouldn't otherwise occur in the parklands.

*Urban Rivers, Creeks, and Canals*. Infrastructure projects that revitalize urban streams and rivers. Typically involve daylighting a stream or river within an urban area. Can be designed to create new and healthy oases in the city while increasing biodiversity and stormwater volume capacity. Can be used as conveyance connections between other cloudburst elements. If small in scale, can help re-establish or create new neighborhood character and social spaces

*Floodable Parks and Plazas*. A sustainable urban drainage system and blue-green infrastructure project designed to not only manage runoff and reduce the impacts of urbanization on flooding, but also contribute to biodiversity preservation, water quality, and the needs of local communities. Opportunity for large retention spaces within urban areas as a solution for local flood resilience. Can be located throughout the watershed and receive stormwater conveyance systems or adjacent water bodies. Can provide a combination of hydrological services including water quality improvements via retention, detention, and infiltration.

Fig. X.X. Floodable parks and plazas.

*Green Streets*. Alternative to conventional street drainage systems designed to quickly collect stormwater. A connection point of cloudburst roads or retention areas. Achieve multiple benefits, such as improved water quality and more livable communities, through the integration of stormwater treatment techniques which use natural processes and landscaping.

*Retention Alleys*. Stormwater management structures designed to slow down, settle, and store run off for a brief period of time. Manage stormwater by installing green infrastructure in alleys which will slow conveyance and possible retention through stormwater planters, hardscape channels, and permeable paving. Typically located upstream of vulnerable low-lying areas. In these streets there should be a retention volume established and detention to slow the peak flow of water reducing flooding downstream. Create a natural break to delineate uses. Reduce heat island effect. Incorporate recycled materials. Reduce light pollution.

*Cloudburst Pipes and Roads*. They divert and move stormwater between runoff sources, retention areas, storage, and waterbodies. Relieve pressure on streets and reduce long-term flood risk. Design must consider conveyance as one element of the drainage system. Design must provide and account for gravity drainage of the area concerned, roadway grading and roadway drainage collection, flooding reduction and protection of property, protection of the natural environment, including all receiving waters and ravines, and future extensions upstream and downstream of any proposed project. Maintaining adequate clearances for pipes is critical. Provide access to safely inspect and maintain these. All work on sewer and drainage pipes must be performed by authorized and knowledgeable entities as allowed by local officials. Construction must not relocate an existing problem to a new location.

*Green Roofs and Green Walls*. Method of capturing and storing rainfall from an elevated point with vegetation in planting media. Reduce runoff volume and treat and store stormwater closest to source while providing urban amenity and cooler environments. Reduce impervious roof surface. Use of native plants is highly recommended. Must harvest filtrate to irrigate the green roof. Standard roofing practices must be followed to ensure structural integrity as well as watertight membrane with overflow drains.

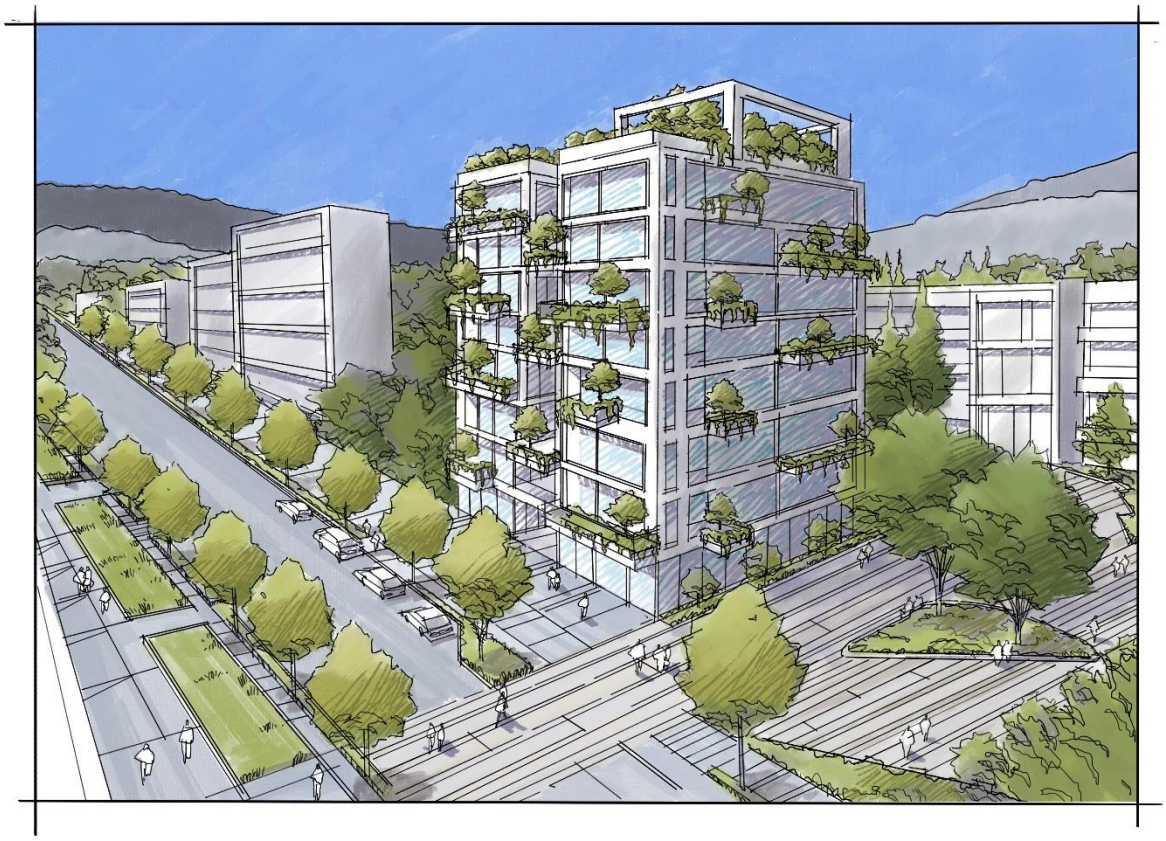

Fig. X.X. Green roofs and green walls.

*Bioswales and Bioretention Areas*. Shallow depressions that collect surface run-off to address non-point source pollution (NPS) issues, where vegetation and soils are used to capture, clean, and infiltrate stormwater runoff. Retain, infiltrate, and treat stormwater at the source and acting as urban amenity that encourage community connections. Establish low impact development in highly developed areas for reduction of pollution and erosion. Evaluate the appropriateness of application per area. Physical constraints to consider are drainage area, seasonal high-water table, and soils. Safety features may be applied but is not required or deemed desirable. Railings or a grate can be used if area is designed with vertical walls. Landscape does much to enhance the performance of bioretention areas. Select plant material based on suitability to the location and preferably native to the locality. Provide maintenance access for inspection and landscape upkeep.

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