SIPA SUPPORT TO VIET NAM FOR THE IMPLEMENTATION OF THE PARIS AGREEMENT

Supported by: Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

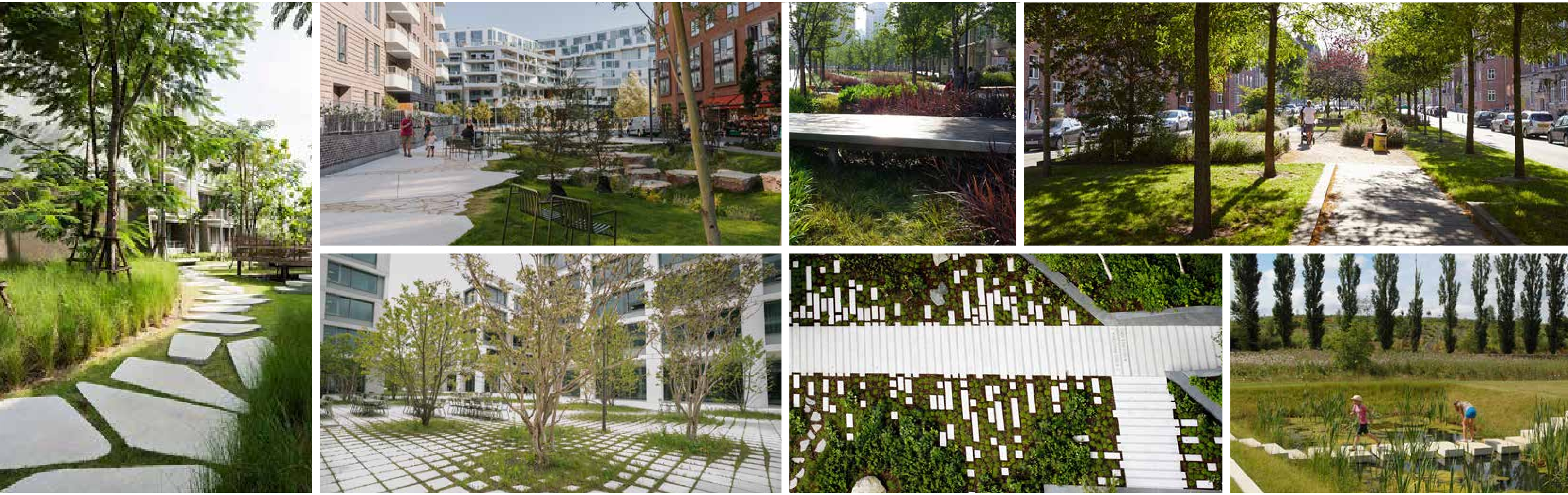
Implementation Guidelines on Water Retention

Dong Hoi city, Quang Binh province
Source: © Hanh Tien

Implementation Guideline

Water retention areas using the Delay - Store - Drain concept

URBAN ECOSYSTEM-BASED ADAPTATION to climate change in Viet Nam



Source: landezine.com

Inspiring examples from around the world for different elements of water retention areas

Source: pxhere.com

FOREWORD

Dear Readers,

Viet Nam is a country characterized by stable economic growth, which has led to a growing middle class and increased urbanization. At the same time, Viet Nam is among those countries most vulnerable to the impacts of climate change. The geographic location and topography of the country, such as its long-stretch of North - South running coastline, make it susceptible to rising sea levels, typhoons, floods and extended periods of drought and heat. This situation requires planned adaptation to the impacts of climate change. The Vietnamese government has acknowledged the issue, and this is expressed in several long-term policies, strategies, and development plans, such as the National Adaptation Plan.

The interrelationship of urban development and growth and the increasing impact of climate change require that adjustments be made to urban planning and development. Public and private investments need to take into consideration intensified rainfall and flooding on the one hand and extended periods of higher temperatures on the other. The integration of elements of Ecosystem-based Adaptation or Nature-based Solutions into urban development is an opportunity for cities to create attractive, green, healthy, and livable urban spaces.

Dong Hoi city in Quang Binh province has developed three Ecosystem-based Adaptation measures as part of a transformative approach to urban development with the support of the International Climate Initiative (IKI) which is an important part of the German government's international climate finance commitment. These measures will serve to showcase the possibilities of green interventions in the urban context. One of the selected measures is a water retention area, which contributes to rain water absorption, urban flood management in rainy season, heat stress reduction, and increased biodiversity, while providing a space for community interaction, sports and recreation during the dry season.

These guidelines were developed along with the water retention project and provide information for investors on technical solutions, project implementation, investment costs and so on, in order to facilitate the replication of such projects elsewhere.

We hope that you find this guideline helpful and feasible for the implementation of your water retention area projects. This significantly contributes to climate-resilient urban environments and to human health and wellbeing.

Sincerely,

Oemar Idoe
Cluster Coordinator
Environment, Climate Change and Agriculture
GIZ in Viet Nam

Phạm Văn Lương
Deputy Director
Department of Natural Resources and Environment
Quang Binh province

Published by
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

Responsibility
Project "Support to Viet Nam for the Implementation of the Paris Agreement" (VN-SIPA)
Daniel Herrmann - Chief Technical Advisor
Patric Schlager – Head of Adaptation Component

Authors
Ngoc Le and Steven Petit

Contributors
Patric Schlager, Nguyen Thi Ngoc Anh, Nguyen Thi Thuong Thuong, Trinh Ngoc Quynh, Anne Theuerkauf, Tran Xuan Quynh, Nguyen Thi Hong Xiem (GIZ)

Photo credits
Hanh Tien, landezine.com, pxhere.com, freepik.com, elements.envato.com, Turenscape, OMGEVING cv, gettyimages.com, habitatassessment.com, shutterstock.com, stock.adobe.com, google.com/maps

Illustrator
Duong Tuan

In cooperation with
HEAT GmbH, Germany

Disclaimer
The findings, interpretations, illustrations and conclusions expressed in this document are based on information gathered by GIZ, partners and contributors under the framework of the "Support to Viet Nam for the Implementation of the Paris Agreement" Project (VN-SIPA). The project is funded through the International Climate Initiative (IKI). GIZ does not, however, guarantee the accuracy or completeness of information, illustrations in this document, and cannot be held responsible for any errors, omissions or losses which result from its use.

On behalf of
International Climate Initiative (IKI)
The IKI is an important part of the German government's international climate finance commitment. Since 2022 the IKI is implemented by the Federal Ministry for Economic Affairs and Climate Action (BMWK) in close cooperation with the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) and the Federal Foreign Office (AA).

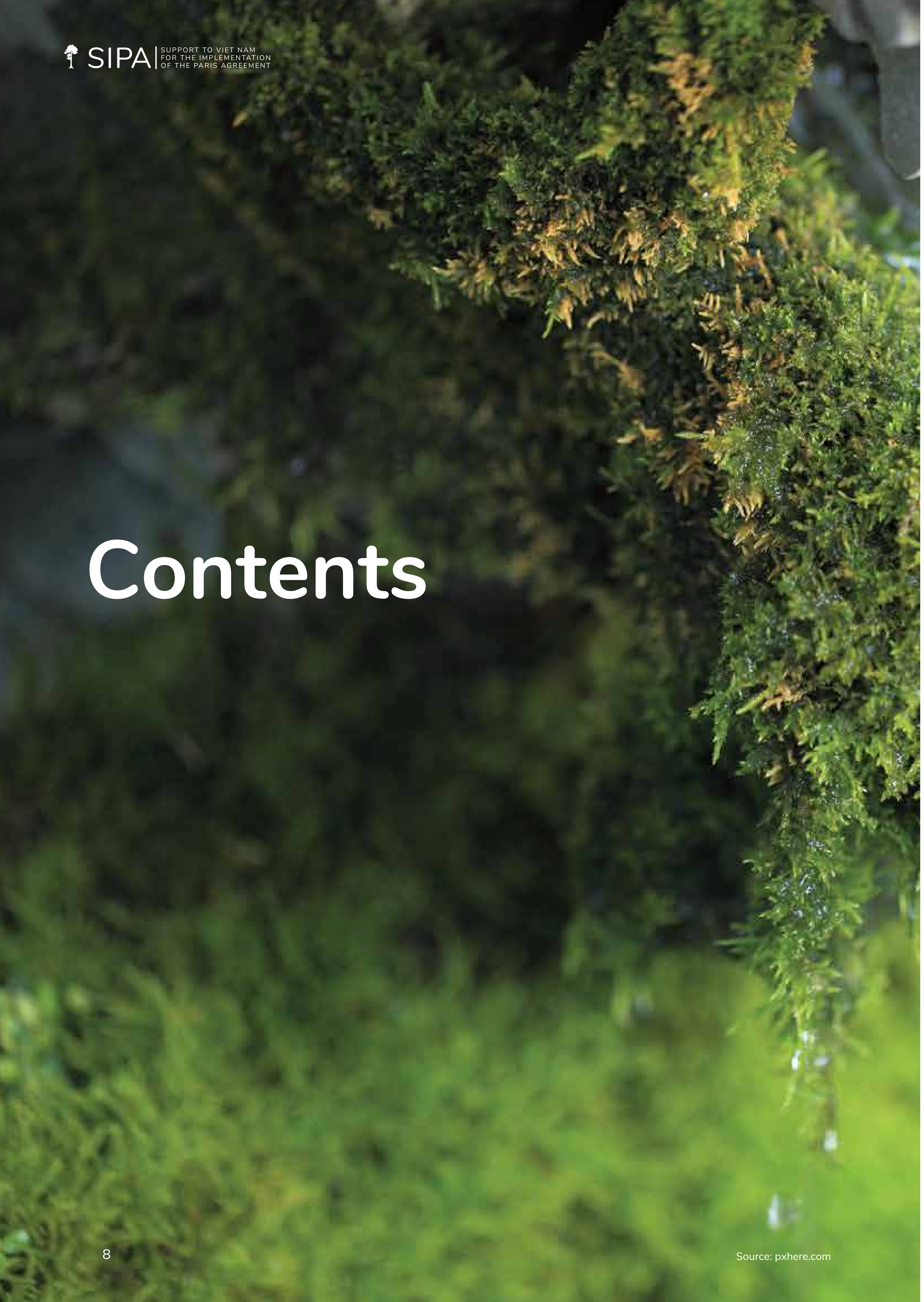
https://www.international-climate-initiative.com/en/

November 2022

ABBREVIATIONS

ADB	Asian Development Bank
DoC	Department of Construction
EbA	Ecosystem-based Adaptation
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
NDCs	Nationally Determined Contributions
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
VN-SIPA	Support to Viet Nam for the Implementation of the Paris Agreement

Source: pxhere.com



Contents

Source: pxhere.com

LIST OF TABLES AND FIGURES

TABLE

FIGURE

Source: freepik.com

Source: elements.envato.com

01

Introduction to the IMPLEMENTATION GUIDELINES

These Implementation Guidelines have been developed by the "Support to Viet Nam for the Implementation of the Paris Agreement" (VN-SIPA) project, funded by the International Climate Initiative (IKI) of the German Federal Ministry for Economic Affairs and Climate Action (BMWK). The project aims to improve framework conditions for the implementation of NDCs and the Paris Agreement in Viet Nam. One of the areas of activity concerns supporting Ecosystem-based Adaptation (EbA) in urban areas in central Viet Nam.

In cooperation with the city of Dong Hoi, Quang Binh province, Viet Nam, the project has identified four specific EbA measures for implementation. The purpose of these guidelines is to provide information on further scaling the measures of developing water retention areas with the use of the delay-store-drain concept. As a nature-based solution, this approach promotes climate change adaptation and bolsters the resilience of built environments in the urbanizing coastal areas of Viet Nam.

The guidelines provide an in-depth analysis of the technical concepts regarding the measures and the financial requirements for users. Additionally, practice examples and recommendations for practical implementation are included. It, therefore, does not provide specific technical standards or mandatory regulations, but rather suggests general principles to guide the development of water retention areas based on the delay-store-drain concept.

The guidelines are written for private stakeholders (i.e., investors and property owners, development banks, etc.) and local authorities who are interested in the development of water retention areas of the delay-store-drain design for new urban developments.

An important note is that these guidelines pertain to a certain scale in the urban fabric. Also, understanding the system as part of the urban fabric is as important as the practical information and applicable know-how obtained from global sources. Even though the document focuses on Dong Hoi city, it is applicable to other Vietnamese medium-sized coastal cities.

The aims and expectations of this document are to provide a set of detailed implementation guidelines. These are expected to bring about better communication and promotion of the use and application of water retention strategies using the delay-store-drain concept. The guidelines focus on four possible applications of delay-store-drain water retention.

+ Permeable pavements
+ Bioretention basins
+ Bioswales
+ Natural corridors

Firstly, these four types of water retention are explained to provide a thorough understanding of the matter. Next, an overview is provided with inspiring international case studies of the four types of water retention. Then, applicability is illustrated by a number of case studies in Dong Hoi city, Quang Binh province, Viet Nam, in particular in the water retention pilot measure of Cau Rao river park.

Finally, the various applications of water retention are explained, and the report ends with the conclusions of the research.

02

Setting THE CONTEXT

2.1 GLOBAL LEVEL

Climate change and rapid urbanization are increasing risks and disaster vulnerability, especially in coastal areas where urban centers are often located and are growing. Climate change hazards and the impacts of rapid urbanization will intensify in the future as a result of increasing population and booming construction activity.

EbA solutions which harness nature-based approaches and utilize biodiversity and ecosystem services for adapting to climate change and urbanization are thus required to reduce vulnerability and enhance the resilience of people and the environment (UNEP, 2020). These solutions should integrate 'green' (ecosystems), 'grey' (engineering), and 'blue' (water) elements for effective climate risk-resilient urban planning and development (GIZ, 2017; UNFCCC, 2020).

Introducing the water retention systems to the urban fabric potentially bestows multiple environmental, social and economic benefits, particularly in meeting the challenges presented by flooding. For example, bioretention areas can reduce surface runoff by 25 - 69% and peak runoff by 12 - 71% (Spaan et al, 2019). A study evaluating the performance of permeable pavements by STEP in 2012 (Toronto and Region) proves that in addition to greatly reducing outflow volumes, the pavements effectively delay and reduce peak flows. Water retention areas with an integrative and holistic approach significantly mitigate flooding. Promoting water retention areas has been widely adopted all over the world. Europe, for instance, has adopted Natural Water Retention Measures (NWRM) to encourage water managers to support the uptake of NWRM in River Basin Management Plans (RBMPs) and to facilitate their implementation via enhanced coordination with other sectors (European Commission, Publications Office. 2014). However, adequate guidelines, laws and regulations need to be well developed in cross-sectoral partnerships to ensure the integrity of water retention systems in order to reap the benefits and improve urban resilience.

2.2 VIET NAM

Fundamental economic reforms in 1986 have resulted in the country's rapid growth and urbanization, which have resulted in environmental pressures due to increasing population and construction booms (see McGee, 2000). Viet Nam's urbanization rate in 2021 of 40.4% is anticipated to rise to 50% by 2050. Viet Nam's construction sector accounts for 43% of total energy consumption and 30 - 40% of CO_2 emissions (Ministry of Construction, 2021).

Against this backdrop, Viet Nam is listed as one of five countries to be most affected by climate change, given the location of a high proportion of the population and economic activity in coastal lowlands and river deltas (World Bank, 2020). Coastal cities and towns of Viet Nam, particularly those in low-lying coastal and delta regions will be affected by uncertain future precipitation trends, extreme events and rising sea levels. There will be serious coastal and fluvial flooding if these urban centers do not implement effective adaptation measures (World Bank and ADB, 2020).

Following its consistent climate change commitment, Viet Nam adopted the Plan for Implementation of the Paris Agreement (PIPA) in 2016 and updated the country's NDC in 2020 with increased ambitions to promote energy efficiency. In 2020, the Ministry of Construction adopted the action plan to implement the Paris Agreement 2020 - 2030 (MoC, 2020), emphasizing the required reinforcement of sustainable building policies and practices. One of the key actions is to promote the development of water retention areas using the delay-store-drain concept.

Source: pxhere.com

2.3 QUANG BINH PROVINCE

Quang Binh province, in the North of Central Viet Nam and with an area of 7,999 km² is known for the UNESCO World Heritage Site Phong Nha Ke Bang National Park and has a growing population 901,984 (reported in 2020). The province has a coastline of 116.04 km to the East and a border of 201.87 km with Laos to the West (Quang Binh province website, 2021). Quang Binh is located in the monsoon-tropical zone. The climate is divided into two seasons. The rainy season lasts from September to March. The annual average rainfall is 2,000 - 2,300 mm. Heavy rains are concentrated in September, October, and November. The dry season lasts from April to August. The average annual temperature is 24 - 26°C.

The urbanization rate of Quang Binh is currently 30.2%. The province aims to reach 40% by 2025 (Quang Binh province website, 2022). Dong Hoi city, categorized as a Rank II city, is the capital of Quang Binh province, with a population of approximately 118,000 inhabitants, anticipated to grow by 5% each year. Given its abundant natural beauty and diverse landscapes, in recent years Quang Binh has attracted significant development projects in the form of resorts, new urban residential areas, shop houses and commercial complexes (Quang Binh DoC, 2021).

However, as a consequence of its geographical location and increasing urban population, Quang Binh province has become increasingly vulnerable to more frequent and intensive climate hazards (i.e., storms, floods, droughts and rising sea levels), which in the past few years have caused substantial damage and losses to the local population and infrastructure in Dong Hoi city.

Quang Binh province has adopted urban ecosystem-based adaptation solutions in the provincial Climate Change Response and Action Plan to improve local climate change resilience.

Source: © Nguyen Duc Ngoc Linh

03

Understanding WATER RETENTION AREAS AS A SYSTEM

With a primary aim to alleviate urban flooding, water retention areas are most effective when planned in a holistic manner. Thus, dealing with resilience challenges with a systems-based approach is a matter of crucial importance.

A design built around a central water system and riverside landscape belts in Haidong Science park, China
Source: Turenscape

3.1 REGARDING THE HIERARCHY OF ECOSYSTEM-BASED APPROACHES

A wide range of methods for water retention is considered: protection, restoration and creation of water retention areas.

- **Protection** refers to the preservation of water retention areas to ensure the sustainability of the benefits these areas provide and to conserve biodiversity
- **Restoration** is related to the rehabilitation of land impacted by degradation, thereby regaining any remaining benefits
- **Creation** is concerned with the development of new water retention areas

Firstly, understanding the existing natural infrastructure in the city for protection, conservation and sustainable management is crucial. For instance, grasslands, wetlands, bottomlands, etc. are a city's most vital water storage areas which help reduce flooding in urban areas. Lest these types of water storage areas are affected by degradation and encroachment, they need to be proactively preserved and managed.

Secondly, numerous factors may exert a negative influence on land areas, impairing their capacity to store water. This presents a need to restore these areas to enhance their performance and function. Therefore, meticulous restoration initiatives integrating floodplains, wetlands, and streams facilitate a better process of reforestation.

The third approach is the creation of new water retention areas, mitigating flooding and strengthening urban resilience. This entails new interventions such as urban forests, permeable pavements, bioswales, bioretention basins, and green corridors.

Each of these water retention areas can be seen as individual interventions, but they are complementary. They can be used for planning and implementation at multiple levels from neighbourhood to city and river basin scales. Multiple connected water retention applications, which form a hierarchical system throughout the city, can maximize the benefits and help to ameliorate urban inundation.

These combined hybrid, blue-green elements enhance the urban landscape while reducing current climatic risks, particularly flooding. The Living with Water Principles illustrated in Figure 1 shows the delay-store-drain approach.
This concept proceeds from the city's water problems across the two precipitation seasons.
(1) Rainy season: Excess stormwater floods urban areas. Drainage is designed to get rid of water quickly.
(2) Dry season: Too little water. The over-extraction of potable water in the summer causes urban areas to subside - making them more flood-prone, and causing the groundwater level to drop, making it harder to obtain drinking water. This delay-store-drain approach raises the sponge capacity of the city by replenishing its aquifers and preventing further subsidence. Water is held locally for greening, resulting in cooling through evapotranspiration. Therefore, it is an approach designed to deal with the complex challenges faced by urban areas.

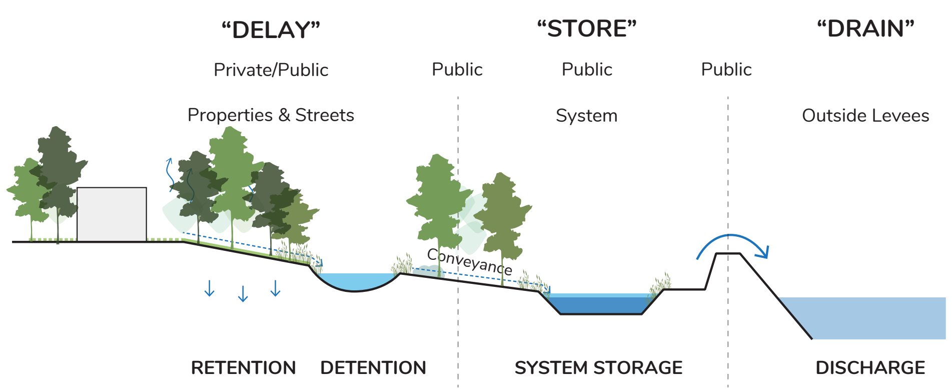


Figure 1: Living with Water Principles with delay-store-drain interventions
Source: Graphic based on GIZ study

3.2 FOUR TYPES OF WATER RETENTION AREAS USING THE DELAY-STORE-DRAIN CONCEPT

There are many solutions based on water retention areas, but in this document, we will focus on urban river parks, including:

- Permeable pavements
- Bioretention basins
- Bioswales
- Natural corridors

The selection of these four types of water retention areas follows from the Cau Rao river park case study in Dong Hoi city, Quang Binh province, Viet Nam. The pictures below and on the next page show how these four types of water retention areas have been installed at the neighbourhood scale and in the context of the urban river park. In the following chapters, these approaches are explained in more detail.


Permeable pavement


Bioetention basins


Bioswale

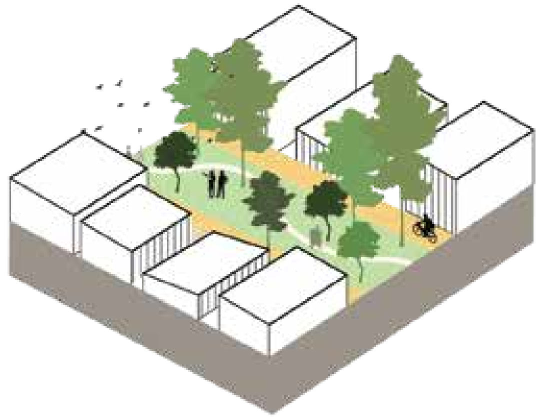

Natural corridors

Figure 2: Four types of water retention areas for urban application: permeable pavement, bioretention basin, bioswale and green corridor
Source: Graphic based on GIZ study

3.3 CONCEPTS OF WATER RETENTION AREAS IN AN URBAN PARK CONTEXT

As climate change proceeds and weather events become more extreme, the need for diverting excess water increases. Stormwater runoff overwhelms urban sewerage systems, which leads to flooding. A common method for managing stormwater is to build water retention areas which collect excess water and release it at a rate that prevents flooding.

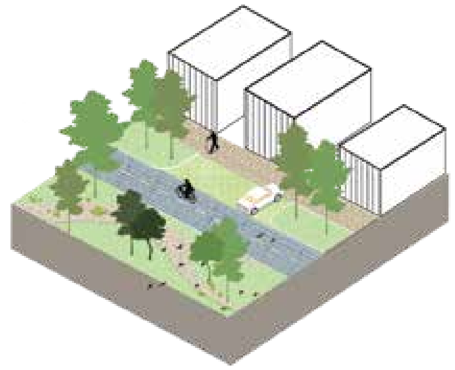
Essentially designed as shallow vegetated depressions, water retention areas are capable of filtering, diverting, intercepting, and altering runoff rate and volume, as well as cleansing the water of particulate pollutants. The effectiveness and treatment capacity of a water retention area are determined by soil quality, the type of vegetation used and the depth of the landform. These areas are deemed especially useful in cities with obsolete systems, especially those that possess combined sewerage systems, experience a considerable amount of polluted runoff or have a lack of permeable surface area. Water retention areas that are well-built and maintained facilitate greater capacity for the stormwater management system. Furthermore, areas that are carefully chosen help eliminate contaminants from runoff and assist in recharging water table and groundwater.

Adaptable to a wide range of metropolitan settings, water retention areas appear in many different shapes and structures depending on their required function and specific circumstances. Water retention systems can be in the form of permeable pavements, detention ponds, retention ponds, bioswales and natural corridors, all of which will be discussed below. Their wetness or dryness is based on the volume of stormwater stored. If they are well designed and implemented, water retention systems confer multiple benefits on urban areas. They can promote biodiversity in the green infrastructure, add aesthetic appeal to the landscape, become an excellent site for recreational and educational pursuits, and become an incentive for citizens to engage in outdoor activities to relieve mental stress, thereby enhancing quality of life.

The four types of water retention areas-permeable pavements, bioretention basins, bioswales and natural corridors, are elucidated in the following sections.

Figure 3a: Infrastructure and ecological solutions to overcome floods and clean up polluted river water at the Yiwu Riverside Greenway, China
Source: Turenscape

3.3.1 PERMEABLE PAVEMENTS



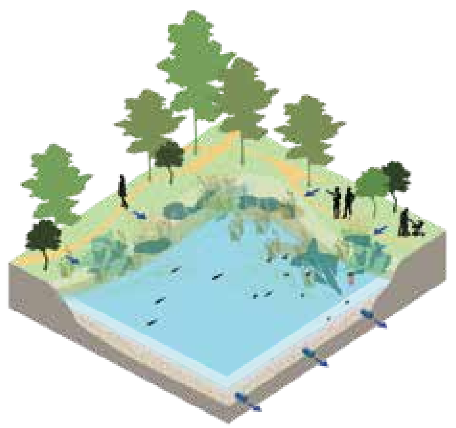
With permeable pavements, rainwater can seep through the surface and into the underlying layers. Before infiltration into the earth, reuse or discharge to a drainage system, the water is temporarily stored. Permeable pavements can be divided into two types: porous pavements and permeable pavements, which are distinguished as follows:

- **Porous pavements** allow stormwater to flow fully through them, e.g. gravel surfaces, pervious concrete, pervious asphalt, or reinforced grass.
- **Permeable pavements** are constructed with well-laid impervious blocks such as interlocking pavers, concrete grid pavers or plastic grid pavers which facilitate water flow between the voids. The technical section of permeable pavements comprises filtration and absorption layers: a surface pavement layer, an upper geotextile membrane, aggregate sub-bases, and the subgrade. These layers differ depending on the amount of infiltration: total, partial or zero infiltration. For example, the zero-infiltration option requires an outlet to drain stormwater, and an impermeable membrane to prevent the polluted water from running into the sensitive underlying groundwater, and/or to decrease the risk of soil instability. Among these layers, aggregate sub-bases can be displaced by geocellular block systems. Due to its high storage capacity (with a void ratio of >90%), if the flooding issue is most prioritized, a geocellular block is preferred.

Permeable pavements can fit into almost any development area and function well as bikeways, parking areas, pedestrian walkways and low-volume roads. They are not suitable for high-volume roads and highways.

Figure 3b: Green square design and public space with permeable pavements in Sint-Agathaplein project, Belgium
Source: OMGEVING cv

3.3.2 BIORETENTION BASINS



BIORETENTION FILTERS/RAIN GARDENS

Bioretention filters or rain gardens are rainwater control structures that absorb and filter water runoff. The stormwater is treated by running it through a shallow vegetated landscape, where pollutants are trapped. The refined runoff is subsequently harvested and delivered to the conveyance system, or exfiltrated into the surrounding soil if site circumstances allow.

DETENTION PONDS

Detention ponds are regarded as a crucial flood control method whose purpose is to slow down water flow and hold it for a short amount of time, e.g., 24 hours. Then, they discharge the water into the sewer system. When it is not raining, they remain dry. Detention ponds reduce peak runoff rates caused by storms, thereby attenuating flood damage in urban areas. Detention ponds can provide a spectacular view in public areas, especially when they integrate playgrounds for children and sporting fields.

RETENTION PONDS

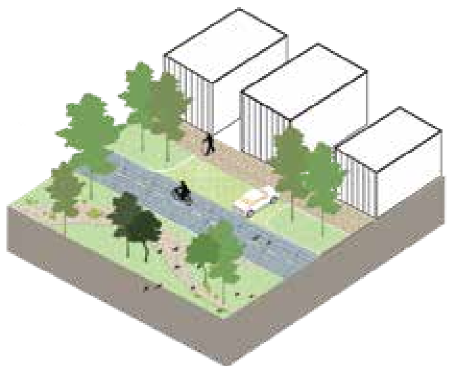
Retention ponds are permanent bodies of water associated with vegetated edges. They differ from detention ponds in that they maintain a pool of water throughout the year, and they improve the water quality. However, retention ponds may cost more to implement than detention ponds as they are generally larger (Leber, 2015).

Retention ponds attenuate stormwater and treat it by providing additional storage capacity to retain runoff and release this at a controlled rate. Water from each rain event is kept and treated in the pond, over time removing pollutants by creating a layer of sediment. Additionally, aquatic vegetation and biological uptake mechanisms afford extra treatment of the water. Thanks to their aesthetic appeal and ecological benefits, they can be successfully incorporated into parks through attractive landscape design.

Figure 4: Maximise water buffer and natural development in the Begijnengracht valley, Belgium
Source: OMGEVING cv

3.3.3 BIOSWALES

Bioswales are linear, shallow, vegetated drainage systems that retain and convey surface water. They collect stormwater from adjacent impervious surfaces, and simultaneously treat and infiltrate stormwater runoff following heavy downpours. Bioswales are the most effective green infrastructure at slowing down runoff rate and cleansing water while replenishing the underlying groundwater table (NACTO, 2013).

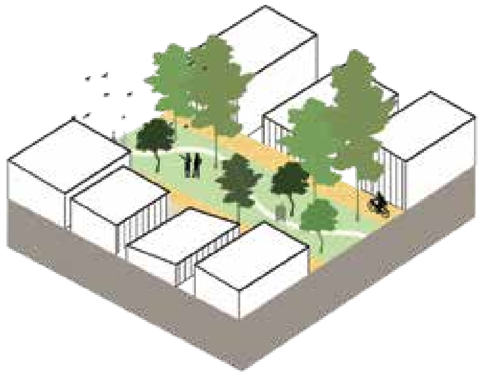


Mostly built on streets and other linear infrastructure, bioswales can make a public space more charming and pleasing to the eye. However, pedestrian trampling on bioswales needs to be dealt with by means of low curbs or vegetation that is strong and able to survive harsh conditions.

Figure 5: Green infrastructure and wastewater treatment integrated into an ecological system in Haikou Meishe River Greenway and Fengxiang Park, China
Source: © Jane Irwin Landscape Architecture

Source: freepik.com

3.3.4 NATURAL CORRIDORS



A natural corridor entails the creation of an appropriate plantation for the site surface that minimizes its environmental impact, preserves and improves current site drainage elements, incorporates an efficient sustainable drainage system, and maintains adequate escape of stormwater from rainfall events that exceed the drainage system's design capacity.

According to Jack Ahern, one of the pioneers of the international green corridor movement, natural corridors are planned or unplanned linear landscape elements which enable numerous cultural, social, ecological, and other uses compatible with sustainable land use (Iberdrola, 2022). These strips of trees, plants, or vegetation usually connect green spaces in a city, thereby establishing a green network of urban infrastructure.

A primary purpose of a green corridor is to link important natural areas in a city via a strip of rich vegetation. Thus, a kind of 'skeleton' is created, capable of shaping greener spaces in cities. Green corridors also protect natural habitats and generally contain the most valuable urban habitat for animal species, allowing them to survive, move, and propagate. Other significant benefits of green corridors include curbing noise pollution and air pollution in the city, preventing heat islands from forming by means of decreasing the temperature, improving quality of life by encouraging physical activity and mental relaxation, representing a great tourist attraction that boosts the city's economy, etc. With the aforementioned advantages, green corridors definitely play an important part in the ecology of the urban landscape. Within this framework, green corridors can be incorporated into cultural spaces, recreational areas, sports amenities, and urban gardens to maximize the benefits that they bring to the urban areas.

In urban landscapes in which distances between green spaces are great and the availability of green corridors is limited, the risk of flooding increases as the infiltration process is limited. Specifically, the ratio of paved surfaces to biologically active surfaces which can absorb, store, and recirculate water is out of balance. Furthermore, the stormwater drainage and sewerage system cannot deal with a vast amount of water. A corollary of this is devastating floods and river contamination. To tackle these problems, green corridors need to be developed in spades which lead to a distinctively green network of urban infrastructure. This infrastructure reduces the pressure on the drainage and sewerage systems and in turn, saves the urban living environment from the threat of flooding or contaminated water discharge.

Figure 6: Natural corridor - Meishe river greenway
Source: © Turenscape

Source: freepik.com

3.4 BENEFITS OF WATER RETENTION AREAS IN URBAN PARKS

TECHNICAL AND ENVIRONMENTAL BENEFITS

- **Minimizing the risk associated with floods:** As mentioned above, the main purpose of water retention systems is to slow down the flow of rainwater and store it to prevent pluvial flooding. These systems usually deal with stormwater running locally at the source, and hence they only serve a catchment area (an area of land into which water flows). Nevertheless, a series of small-scale systems implemented across the catchment area will help to mitigate the consequences of greater floods in downstream regions. Furthermore, trees from natural corridors boost rainwater interception in urban areas, lowering the risk of local floods and peak stormwater loading on the sewerage system.

- **Cleansing water and optimizing sediment management:** Water retention areas are often used to absorb and filter the first flow of stormwater runoff, which contains the largest proportion of contaminants. Various types of water retention areas have vegetation, gravel and soil that operate as filters, eliminating many contaminants before returning the filtered water to the natural environment.

- **Reusing Water:** Many water retention facilities can be utilized locally to capture, treat, and manage water for reuse in buildings or landscapes. Rainwater harvesting can exist on a variety of scales, from individual properties to entire sites. Reusing rainwater for non-potable uses like irrigation and toilet flushing can contribute to sustainability goals while also reducing potable water demand.

- **Preventing soil desiccation by slow infiltration:** By purifying rainfall and slowing the runoff, water retention areas allow water to infiltrate gradually into the soil and then into the groundwater layer. This helps the soil to absorb rainwater and keeps moisture in the soil profile, thereby helping to reduce the formation of hard, impermeable soil, and to simultaneously minimize flooding.

- **Maintaining and encouraging biodiversity:** Plants, trees, and other vegetation are frequently used in retention areas to slow and hold water while also providing filtration. These can be tailored to meet the needs of local biodiversity. At the same time, these can create ecological corridors. They can also include a wide variety of plant species, from wetland species to familiar garden varieties. Water retention areas should be built to complement and improve the ecology of the area, but the effects of species selection and maintenance requirements on the ability of existing habitats to operate successfully should be considered.

- **Facilitating carbon sequestration:** Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. Water retention areas sequestrate carbon biologically. As carbon is not emitted into the surrounding air, the greenhouse gas has less impact on the atmosphere, leading to improved air quality.

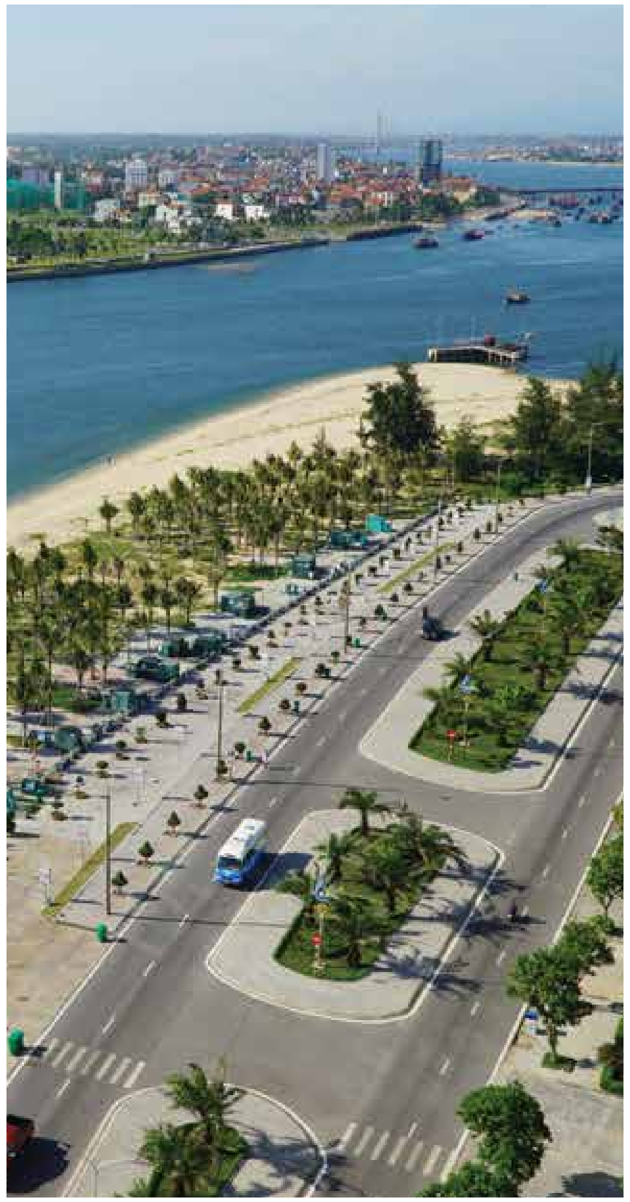
- **Creating microclimates and reducing heat stress:** Water retention areas consisting of water and vegetation with their evapotranspiration can help to moderate local temperatures and reduce the impact of the urban heat island effect. By producing shade, moderating heat, and filtering the air, these water retention areas create microclimates and mitigate heat stress.

SOCIAL BENEFITS

- **Stimulating interpersonal and cultural interaction:** Water retention areas are perfect spaces for informal social gatherings (Kim and Song 2019), building a more harmonious and stronger community bond. Also, these areas may be incorporated into traffic control infrastructure to ensure more secure use of public spaces. Natural corridors burnish the image of the urban areas alongside architecture, establish an urban identity and elevate the beauty of the space's other elements to an art form.

- **Promoting educational pursuits:** Water retention areas present an opportunity to educate and involve communities in water management, as well as foster a greater understanding and respect for urban water. If implemented in schools, they can provide an useful learning and playing opportunity for students and other youngsters.

- **Creating healthy environments for users:** Designing green spaces and public realms with water retention areas that function well in both wet and dry conditions can provide useful community recreational spaces and vital environmental infrastructure. Sports fields, squares, courtyards, playgrounds, landscapes around buildings, urban parks, green corridors, and woodlands are all examples of open spaces that can be combined with water retention facilities. These can also help meet open-space development goals if they are built to be multi-functional.



Source: © Hanh Tien

04

Implementing WATER RETENTION AREAS

The previous chapter explained that water retention areas work as an integrated or holistic system with the hierarchy of ecosystem-based approaches. This chapter focuses on the implementation of such projects on various scales and specifically on their implementation in Cau Rao river park in Quang Binh.

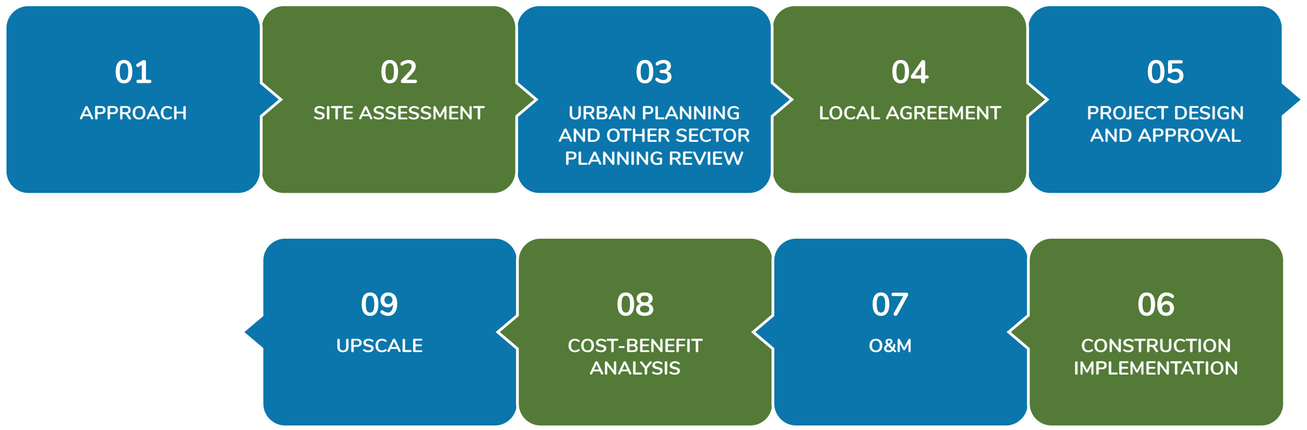


Figure 7: General implementation process according to Viet Nam's legal framework
Source: Graphic based on GIZ study

There are nine steps for implementing water retention areas according to Viet Nam's legal framework, as illustrated in Figure 7, above. These guidelines do not follow the exact steps of Viet Nam's legal framework but give a general process overview for implementing water retention areas. Chapter 4.1 will focus on the first six phases that need to be considered when implementing these measures, including Site assessment, Goal setting, General design considerations, Maintenance, Stakeholder engagement and Project approval. Chapters 4.2 and 4.3 will discuss the installation and cost of construction, respectively.

4.1 PLANNING WATER RETENTION AREAS ON DIFFERENT SCALES

Water retention areas should be considered on a variety of spatial scales. The differences in implementation at different scales are described in this section. On a regional scale, identifying the upstream source location and providing the water retention area at a distance from the impacted urban areas can delay the runoff and address flooding before the excess water reaches the city. For example, in a severe storm, an upstream forest/natural corridor can be very effective in holding the water, reducing strain on the downstream system, and safeguarding river systems. On the other hand, water retention designs inside the city or residential neighbourhood can be cleverly incorporated into the built environment, creating green livable towns and enhancing urban resilience in response to increased risks posed by climate change.

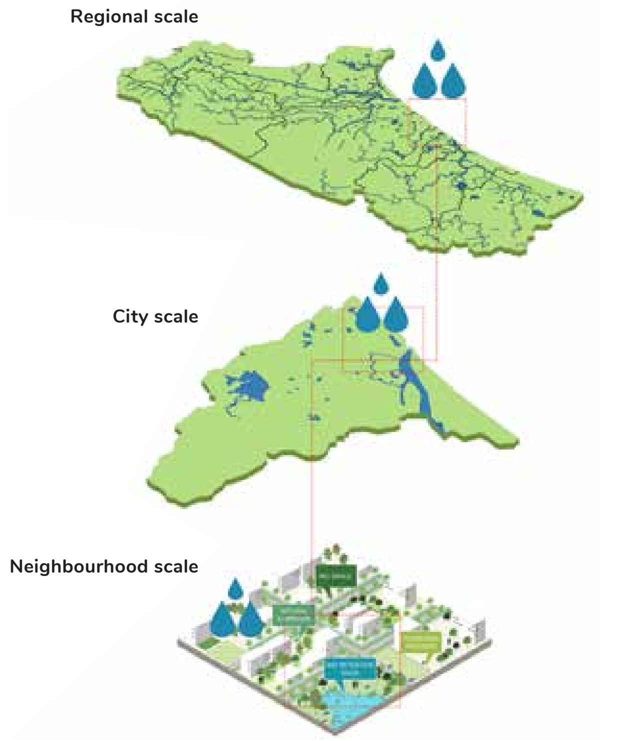


Figure 8: Water retention areas on different scales
Source: Graphic based on GIZ study

4.1.1 CITY SCALE

Water retention areas at the city scale complement the land use plan and support the city's flood management strategy. The ecological and landscape structure of the city is core to defining suitable potential water retention types and locations. A comprehensive study of several distinguishing characteristics, such as topography, hydrology, climate, and ecology, form an overall understanding of the water system. This then allows the creation of a city's well-functioning water network, meeting the flood challenges. Some examples that can be provided at the city level are:

- Bioretention basins in lower urban areas to collect and store water
- Bioswale networks or green corridors to redirect the water into the main water storage areas
- Urban green corridors along rivers/coastline to protect inland areas from flooding due to high tides
- Natural corridors to increase infiltration capacity

4.1.2 NEIGHBOURHOOD SCALE

At the neighbourhood scale, smaller implementations can be applied that are very effective at increasing stormwater retention capacity. Multiple installations can be implemented to form resilient clusters, which reduce pressure on the overall infrastructure, and at the same time fit into the city's general design aesthetic. Particularly at this level, the collaboration between public & private stakeholders is key to success. Some examples at the neighbourhood scale are:

- Permeable pavements to delay the water runoff
- Bioswales along roads/pathways to delay runoff and redirect excess water
- Natural corridors such as green streets and corridors adjacent to urban infrastructure to slowdown the stormwater and allow infiltration into the soil
- Smaller-scale retention basins such as bioretention filters/rain gardens, wetlands, rainwater retention ponds to store water

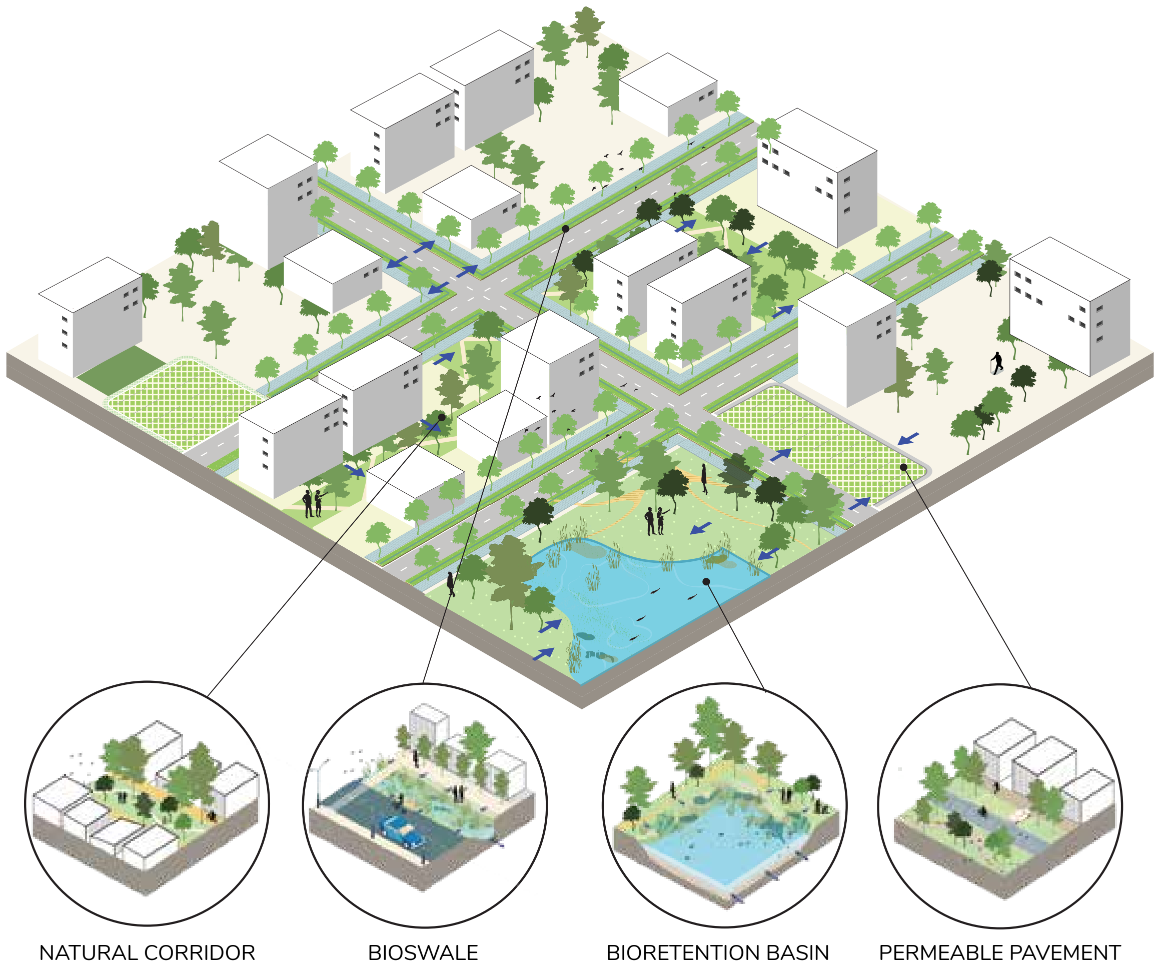


Figure 9: Four types of water retention areas on the Neighbourhood scale: green corridor, bioswale, bioretention basin and permeable pavement
Source: Graphic based on GIZ study

4.1.3 SITE ASSESSMENT

Planning a water retention project requires a thorough site assessment of the local climatic-geographical conditions to inform the optimum design and installation requirements. A comprehensive site assessment examines climate, hydrology, soil and water conditions on meso- and micro-level and takes into account the existing built environment.

FLOODPLAIN

Floodplain water retention facilities should be chosen and developed correctly, with consideration given to the expected high groundwater table and vulnerability to erosion. Grading and the development of surface elements that could be ablated in a flood should be limited in design. Surface discharge should be distributed. Water retention areas should be designed with attenuation periods that allow them to empty gradually within 48 hours of any rainfall.

Secondly, understanding other flows, such as runoff from neighbouring properties, and ensuring that buildings do not obstruct runoff routes are also necessary.

Lastly, it is critical to determine if the site is located upstream or downstream of flood risk regions at the early design stage. This information can impact water retention area design criteria.

GROUNDWATER

The depth of the water table beneath the ground must be determined. High groundwater levels might cause flooding or damage to deep water retention structures. In this case, limiting infiltration is recommended by using liners[1].

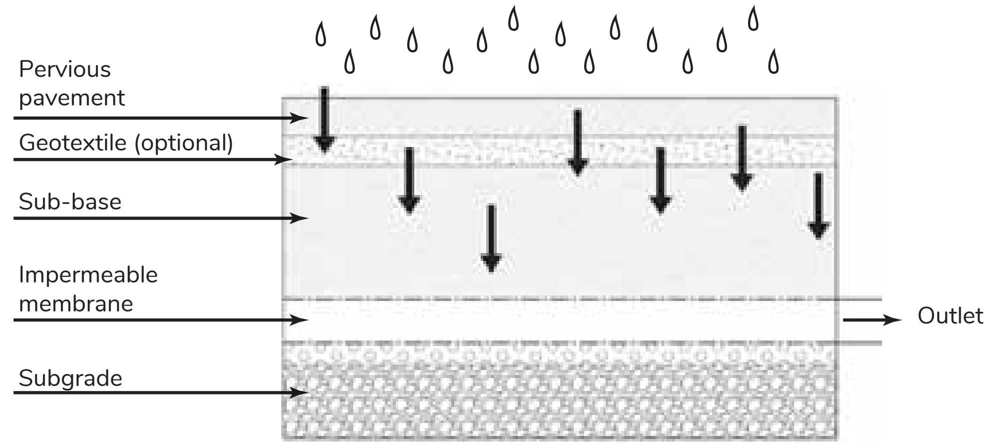


Figure 10: Example of pervious pavement system with liner – no infiltration
Source: Redrawn by OMGEVING cv based on Woods Ballard et al (2007)

TOPOGRAPHY

On flat land, managing surface runoff can be more difficult than on a moderate slope because it is not possible to rely on gravity to move the water. In these locations, trying to keep water runoff on the surface as much as possible and managing runoff near to its source is the best option. For example, using roadside kerbs or bioswales to channel the water along the surface. Pumping should only be used as a final option after all other solutions have been exhausted.

Because higher slopes increase runoff velocity, these locations demand extra care when incorporating water retention areas. Infiltration is not advised near extremely steep slopes because it may affect slope stability. On higher slopes, however, check dams or staged storage can be employed to limit runoff rates. Another approach is to build the site such that runoff is carried on platforms, similar to how switchback roads in rocky terrain are built. On slopes, bioretention and wetland components might be staggered in a terraced pattern.

Source: gettyimages.com

SOILS & GEOLOGY

It is important to first understand the geology of the site, as a permeable layer may exist beneath shallow impermeable strata, allowing infiltration to occur at a greater depth. Where soil is poorly permeable, the water retention area should promote attenuation and water treatment above ground or adjacent to the surface. In particular regarding permeable pavements installed above impermeable soil, all water passed through the sub-base should be carried by an outlet pipe into the main drainage system to mitigate flooding on the pathway.

CONTAMINATED SOIL

Concerning contaminated soil areas, the water retention system should incorporate a liner to restrict water flow to the surface. This results in zero infiltration which help to avoid the transmission of impurities into the deeper soils and protects the vulnerable aquifers beneath.

EXISTING INFRASTRUCTURE

Existing infrastructure should be evaluated when installing water retention areas on brownfield or pre-developed sites to provide the optimal solution. It is necessary to know the position and capacity of current the drainage system. Other subterranean infrastructure, such as utilities, have to be identified and taken into account when designing and implementing water retention facilities.

RUNOFF CHARACTERISTIC

Designing water retention areas in industrial areas requires careful management to make sure that polluted water is well treated, isolated from the other clean water runoff, and does not infiltrate the underground water. Therefore, a system with a liner and spill isolation is recommended. In addition, a series of different water retention types should be implemented to guarantee that water is subjected to a range of filtration systems and that flow is attenuated to allow pollutants to settle out.

PROTECTED SPECIES OR HABITAT

In developed places, water retention areas with their vegetation and water surface can help boost biodiversity and improve ecology. Nonetheless, their design should take current ecological circumstances into account. Preliminary site analysis should identify areas of interest, such as nature preserves, protected species habitats, and locally significant ecosystems. These areas should be protected or enhanced by water retention areas through smart integration and careful long-term planning to ensure that the habitat is not destroyed during maintenance.

Source: freepik.com

OWNERSHIP AND MAINTENANCE

At the beginning of the project, detailed consultation should be carried out with the adopting stakeholders to guarantee that water retention areas are developed according to the criteria of the adopting authority. The adopter could be a municipal government, a roads authority, a property owner, or a water company, depending on the local requirements and circumstances. When acceptance is unknown, it is best to build for flexibility with simple and minimal maintenance solutions. Table 1 below provides a decision matrix to assist in choosing the most effective solution.

Table 1. Selection matrix for site conditions

		Permeable pavements	**Bioretention basins (bioretention filters/ detention/ retention ponds)**	**Bioswales**	**Natural corridor**
Floodplain	Located in the flood plain?	•	x	•	•
Groundwater	Groundwater less than 3 meters below the ground surface?	• With liner and underdrain (no treatment)	• With liner	• With liner	•
Topography	Sited on a flat site? (<5% gradient)?	• Source control	• Try to keep flow above ground to	• Careful to provide some gradient	•
	Sited on a steep slope (5-15% gradient)?	• If terraced	x	• If installed along contour	•
	Sited on a very steep slope (>15% gradient)?	x	x	x	•
Soils and geology	Impermeable soil type (e.g. clay based type)?	• With underdrain (no treatment)	•	•	•
Contaminated land	Are there contaminated soils on site?	• With underdrain (no treatment)	• With liner	• With liner	•
Existing infrastructure	Are there underground utilities in the area?	• If possible, relocated into a marked corridor for future maintenance	x	x	•
Runoff characteristics	Suitable for inclusion in high-risk contamination areas?	• With liner and spill isolation	x	• With liner and spill isolation	•
Protected species or habitat	Proximity to designated sites and priority habitats?	•	• If designed and maintained appropriately	•	•
Ownership and maintenance	Can the feature be designed for adoption?	• Dependent on design and local adoption policies			

x unsuitable
• suitable

Source: Aecom (2003)

4.1.4 GOAL SETTING

It is important to identify upfront the goal of a water retention facility, as this will influence the design, construction and level of maintenance required for the system. The following table presents goal-setting considerations for each type of water retention application.

Table 2: Goal setting

Performance	Permeable pavements	Bioretention basins (bioretention filters/ detention/ retention ponds)	Detention ponds	Retention ponds	Bioswale	Natural corridors
Peak flow reduction	Good	Medium	Good	Good	Medium	Medium
Volume reduction	Good	Good	Medium	Poor	Medium	Medium
Water quality treatment	Good	Good	Medium	Good	Good	Medium
Amenity potential	Medium	Good	Good	Good	Medium	Good
Ecology potential	Poor	Medium	Medium	Good	Medium	Good

Source: Adjusted from Woods Ballard et al (2007)

Source: freepik.com

4.1.5 GENERAL DESIGN CONSIDERATION

TECHNICAL

- **Slope and stability:** In most ground conditions, bioretention areas can be utilized. However, within steeper catchments, they are more difficult to integrate well. Regarding bioswales in particular, low runoff velocities are necessary for contaminant removal and erosion prevention, hence the longitudinal slope should not exceed 4% (Woods Ballard et al, 2007). For areas with grades steeper than 3:1, there should be a leveling plantation or terrace dug into the slope to prevent erosion and instability (DDOE 2012).

  Unless a full risk analysis has been conducted by a fully qualified geotechnical engineer or engineering geologist, unlined bioretention areas should not be used in locations where infiltrating water may cause slope instability or foundation problems, such as in landslide-prone areas, at the top of cuttings or embankment slopes, or close to building foundations. The impacts of ponding water on the structural capacity of the underlying soils must also be carefully evaluated, and slopes and collection systems must be used to mitigate the dangers connected with ponding water.

- **Subsurface soils and groundwater:** The seasonal high groundwater table must be more than 1 m below the base of the facility in bioretention zones planned for infiltration, and the design must conform to the environmental regulator's laws on infiltration and groundwater protection. Where infiltration is not necessary, the liner should be placed above the seasonal high groundwater level. To fully function, infiltration devices require a minimum infiltration rate of 1.0 x 10^{-6} m/s (Woods Ballard et al, 2007). On brownfield sites, unlined bioretention spaces should not be used unless the pollutants and their impact on the environment have been thoroughly assessed. If there is a risk of groundwater pollution, unlined bioretention sites should not be used to remediate runoff from contamination hotspots.

- **Substrate:** A loamy soil capable of infiltration and supporting a healthy vegetative cover should be used as the substrate. Organic manure or plant waste can help to improve the soil. To improve absorption and water purification, a secondary filter layer of sand, gravel, or similar drainage material is often put below the substrate.

- **Space requirement:** Permeable pavements are commonly used as an alternative to impermeable surfaces, and they don't require any more development space. With the high proportion of road surface necessary in any metropolitan area, this drainage technique has a lot of potential.

  Concerning bioretention filters, they typically take up 5 - 10% of the total site area. And with detention/ retention ponds, the are a should be 3 - 7% of the upstream catchment (Woods Ballard et al, 2007). They can, however, be incorporated into the site landscaping or built for multiple purposes with creative site design.

  Bioswales require significant land-take because of their shallow side-slopes. Therefore, they are difficult to incorporate into densely populated metropolitan areas with limited space.

  Regarding natural corridors, an appropriate three-dimensional space is required for trees to establish their roots securely. The minimum width and depth for growing a mature tree is 1.5m. Nevertheless, the slope of the corridor and density of vegetation are also crucial considerations.

- **Vegetation:** The careful selection of plant species is critical to the efficient operation of water retention zones. Native floodplain plants that can withstand a wide range of soil saturation and flooding and are resistant to environmental stress are often the best fit for the changing conditions. However, changes in plants and soils must be taken into account, which might range from places of regular flooding to areas that are rarely flooded.

  Trees and shrubs must be hardy and able to tolerate ground vibration, air and water pollution, and other urban stresses. Trees must be pruned on a regular basis to maintain a safe distance from roads, pedestrians, buildings or other infrastructure in the long term.

  Plant species that provide significant benefits should be encouraged. This might include everything from tree selection for maximum carbon sequestration and heat reduction to plant species selected for aesthetic value or to provide habitat or food for wildlife.

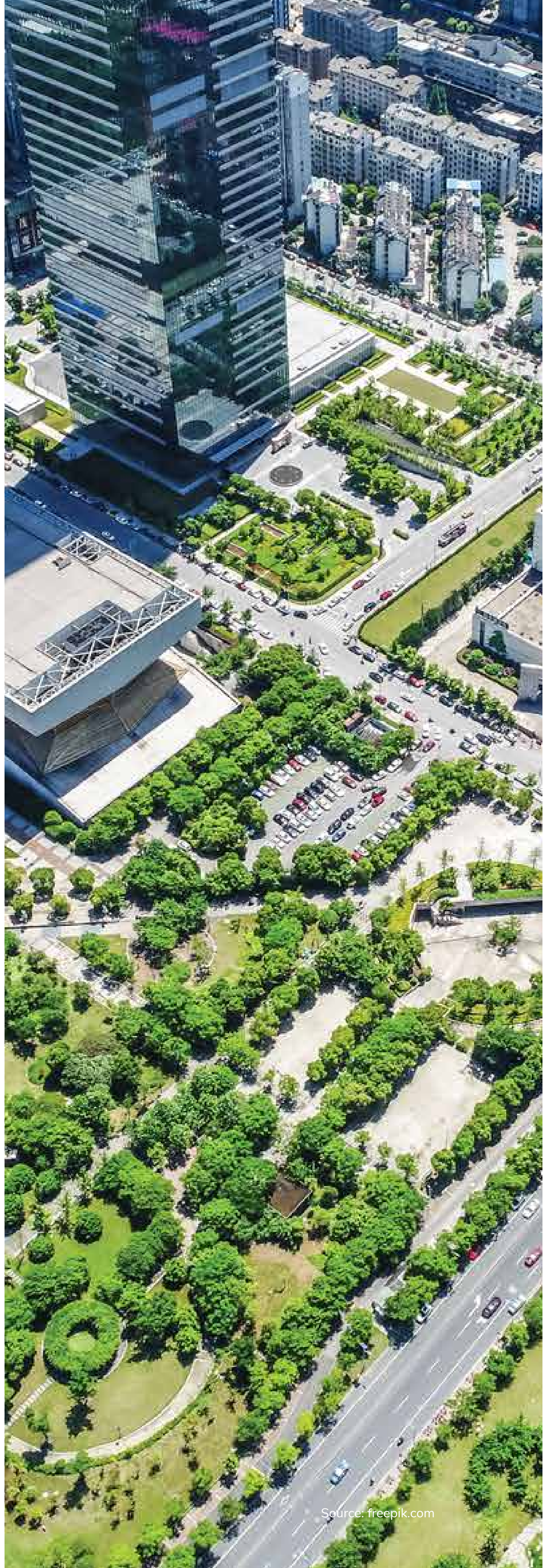
- **Connection to existing drainage system:** Water retention areas can be successfully connected or merged with sewer systems through an overflow outlet or underdrains.

  Regarding areas with unstable soil, it is necessary to prevent the build-up of water above the subgrade. At the formation level, a set of perforated pipes should be constructed to redirect rainwater that exceeds the subsoil's infiltration capabilities to the drainage network.

  Regarding vulnerable areas that have soil with critically low strength and permeability, sensitive groundwater to be preserved, or which need to collect water for reuse, a system with no infiltration is recommended. When the filtered water leaves the sub-base, it is channeled by perforated pipes into the main drainage system and the subgrade is protected by an impervious membrane cover above.

SITE SUITABILITY

- **Urban function:** Residential, industrial, and commercial developments, roads and infrastructure networks, parks, and parking areas are all appropriate areas for installing water retention facilities.
- **Urban density:** Water retention areas are frequently associated with substantial green spaces, although there is a variety of water retention facilities that can be easily integrated into dense urban environments. Water retention areas should be designed as multi-functional spaces and linked to form a system to control runoff near its source, avoiding the demand for vast storage sites. Bioretention filter/rain gardens, permeable pavements, and bioretention tree pits are examples of space-efficient water retention areas.
- **Scale:** On a neighbourhood scale, it is possible to create permeable pavements, bioretention filters in neighbourhood parks and bioswales or tree canopies along roads. At the city level, bioretention basins or natural corridors can be implemented.
- **Incorporated into the urban landscape:** Water retention areas can be constructed as part of a sewage system expansion or roadway renovation project and stormwater drainage implementation for new development areas. Natural corridors can be planted as part of a street improvement programme and can transform underutilised infrastructure, open spaces and new urban developments.



Source: freepik.com

4.1.6 MAINTENANCE

To minimize blockage by sediments, water retention systems require thorough and regular maintenance. Litter and plant waste should be removed, and degraded sections should be restored. The basins should be inspected weekly to identify any additional maintenance needs.

For plantations, maintenance requirements differ greatly between habitats. Irrigation needs vary widely according to plant species, soil type, and current weather conditions.

The table below provides an overview of key components of operation and maintenance for several types of water retention areas.

Table 3: Typical key components operation and maintenance activities

O&M activity	Permeable pavements	Bioretention basins	Bioswale	Natural corridors
Regular maintenance				
Inspection	●	●	●	●
Litter/debris removal	●	●	●	○
Grass cutting	○	●	●	●
Weed/invasive plant control	○	○	○	○
Shrub management	○	○	○	○
Shoreline vegetation management		●	●	
Aquatic vegetation management		●	●	
Occasional maintenance				
Sediment management	●	●	●	
Vegetation/plan replacement		○	○	○
Vacuum sweeping and brushing	●			
Remedial maintenance				
Structure rehabilitation/repair	○	○	○	○
Infiltration surface reconditioning	○			

● Will be required
○ May be required

Source: Ellis, Shutes and Revitt (2003)

Source: freepik.com

4.1.7 STAKEHOLDER ENGAGEMENT

Implementing water retention areas on the city scale will mostly be the responsibility of the government. However, it is important to cooperate with different sectors to ensure synchronized city planning. There should be a consensus between the following departments:

- Department of Planning and Investment
- Department of Construction
- Department of Transportation
- Department of Environment and Natural Resources
- Department of Agriculture and Rural Development
- City People's Committee

On the neighbourhood scale with the engagement of private investors, there should be a clear discussion between the public/private stakeholders to ensure a well-functioning water retention system, following technical standards and creating value for local people.

Accordingly, water retention projects require consultation between different professionals regularly or throughout the design and construction phases:

- Hydrogeologists or water resource engineers should be involved at the beginning.
- Urban planners/architects should be consulted from the beginning of the planning stage.
- Structural engineers are needed to ensure comprehensive design development.
- Plant biologists are required to advise on the selection of suitable plants for the project's goal and local conditions.
- Horticulturalists/soil scientists are, for example, necessary to advise on the required volume and quality of growing media to achieve the expected plant height and cover.

Engaging with specialized experts early in the planning phase is critical to ensure good structural and biogeographical conditions for plant growth (Hunter et al. 2014, p. 105). In all cases, advice should be sought from a specialist to define the most suitable design, structure and component materials for water retention systems and the maintenance responsibilities and contract arrangements should be made clear to owners/managers and installation contractors from the beginning of the planning phase.

Project planning	Project design and approval	Project construction/ Installation	Project monitoring	Project handover
• Idea discussion and agreement • Consultant selection • Site assessment • Goal setting • Stakeholder engagement	• Design and technical document development • Design auditing • Approval of the Project design and other related technical document	• Permeable pavements • Bioretention bains • Bioswales • Natural corridors		

Figure 11: Stakeholder roles and responsibilities
Source: Graphic based on GIZ study

4.1.8 PROJECT APPROVAL

There are two steps to secure the final project approval: (1) design concept approval; and (2) technical design approval. Water retention projects need to meet relevant technical and safety standards under national and local legal frameworks and in many cases need to follow local building approval/permit procedures. The superordinate laws for all projects to be followed are the national technical regulations and standards for approval:

- National technical regulations on construction planning QCXDVN 01:2021/BXD
- National technical regulations on technical infrastructure works in urban areas QCVN 07:2016/BXD
- Drainage and sewerage - External networks and facilities - Design standard TCXD 7957:2008

River green corridors: There are some policies addressing protecting water resources (Law on Water Resources and Decree No. 43/2015/ND-CP, regulating the establishment and management of water source protection corridors). This requires a buffer from 5 m upto 30 m and above for the waterway depending on its characteristics. However, the policy only focuses on protecting the water, reducing pollution and landslides, preserving the habitat, and creating a public space. It does not point out the function of these as green corridors for minimizing flooding in the city.

The Law of Urban Planning (Resolution No. 51/2001/QH10; Congress) states, "Do not encroach on lakes, natural water surfaces or change other topographical features, adversely affecting natural conditions and urban landscapes".

Article 2.8.2 of QCXDVN 01:2021/BXD also prescribes that surface water drainage system planning must ensure the area and volume of the reservoir system to regulate surface water; exploit low-lying areas for temporary storage of rainwater; increase the surface area of water absorption for traffic works, yards, technical infrastructure and other public areas. Existing urban areas must retain, renovate, and upgrade existing lakes, rivers and canals to ensure storage volume and regulate surface water.

Street tree canopies: There is some policy dedicated to the street section that has space for planting trees. However, whether one should completely follow this policy depends on the street type, and therefore it is deemed not compulsory. The dimension varies with a minimum of 1 m for bushes, 2 m for 1-row trees and 5 m for 2-row trees.

These guidelines do not go into detail in this regard, and rather focus specifically on the technical procedures of installing water retention areas.

4.2 INSTALLING WATER RETENTION AREAS

The design process and implementation strategy for the river park results in a blue-green network in which the four previously described types of water retention apply:

- Permeable pavements
- Bioretention basins
- Bioswales
- Natural corridors

In the following chapters, the technical installation of these water retention types is explained.

4.2.1 PERMEABLE PAVEMENTS[2]

There are many types of porous materials suitable for pavement construction. In Viet Nam, permeable asphalt and permeable concrete are quite new measures, still under experimentation and testing. The appropriate existing technology is the permeable interlocking block, which may allow for easier replication and maintenance in the local context. Thus, this section will focus on the implementation of this popular material - grass block pavers.

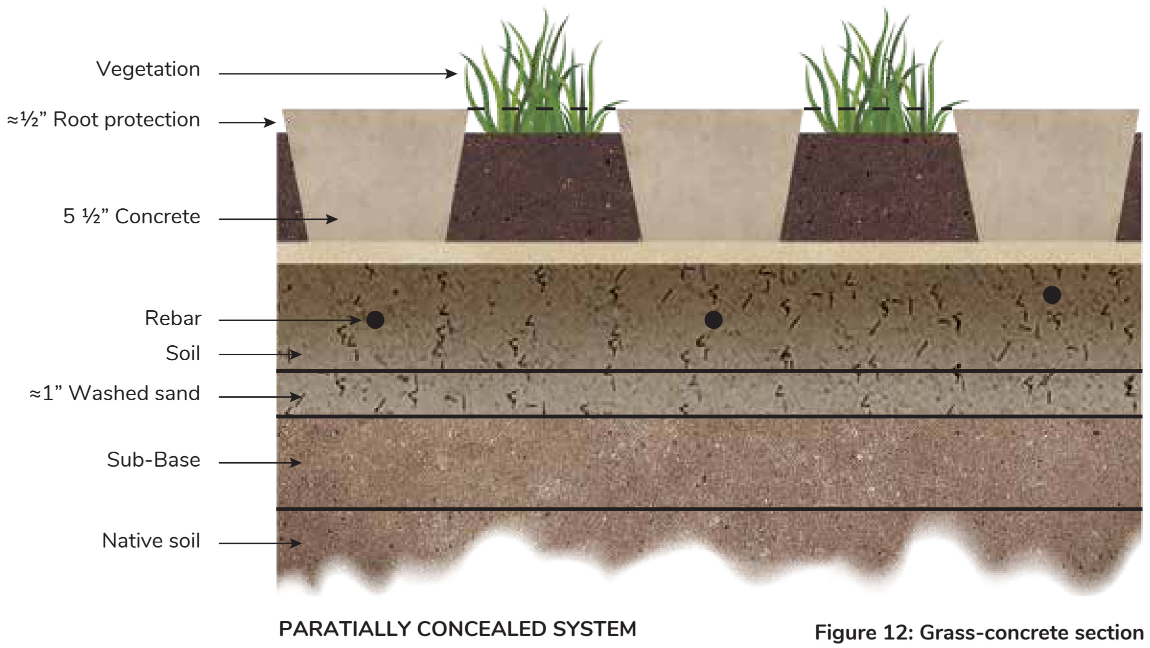


Figure 12: Grass-concrete section
Source: Redrawn by OMGEVING cv based Falak (2020)

[2] In these guidelines, "pavement" is used as a general term to refer the surface of a road or site where the project could intervene. It could encompass the construction in different sites. For example, for the pilot in Quang Binh, permeable pavements were implemented at the parking lot and playground area for children.

STEP 1
PREPARE THE GROUND FOR GRASS BLOCK PAVERS

- This is the first and most important step in paving. The requirement is that the ground must be firm, well compacted and have an appropriate slope.
- Screed the substrate to a specific grade to allow for the most effective drainage. If the ground is too flat, water will not drain properly, creating soft, muddy ground in the area.

STEP 2
SKETCH THE OUTLINE OF THE FOUNDATIONS FOR BRICKLAYING

- Geodetic survey, measuring poles, tensioning lines, or marking with lime from the outermost boundary of the paved area
- In the case of a pre-existing pavement, the existing boundary can be used.
- If building a completely new pavement, define an outline for the pavement
- Paint, spray on the ground can be used along the intended pavement.

STEP 3
CLEAN UP THE SURROUNDINGS, REMOVE WEEDS, AND INSTALL THE DRAINAGE

When preparing the ground for a new pavement or for paving a parking lot, it is necessary to:

- Remove weeds and install drainage pipes to drain underground water
- These pipes should be installed at least 3-5 cm above the ground and run on a slope.

Source: pxhere.com

STEP 4
SPREAD CRUSHED STONE AND COMPACT THE FOUNDATION LAYER TO AVOID FUTURE SUBSIDENCE

- Cover the base with a layer of crushed stone, spread it on the surface to a thickness of 5-10 cm
- Use a compactor or roller to compact the crushed stone to create a solid pavement bed
- During the process of planting the lawn, add 1-2 cm of sand and water evenly
- Use a trowel or screed to create a flat surface, and place bricks near the area to be paved

Figure 13: Screeding the substrate in preparation for laying the pavers
Source: stock.adobe.com

STEP 5
LAYING THE GRASS BLOCK PAVERS

- Prepare the base of the pavement first, then start construction
- Start laying the pavers in the middle and continue to pave up to the boundaries of the pavement
- This will make the construction process simple, aesthetic and less labour-intensive.
- However, it is necessary to use a brick cutter to cut the bricks to fit the required area.
- Set aside the required uncut pavers for the boundaries. They should only be cut when the main part of the pavement has been laid with intact pavers.

Figure 14a: Laying pavers on the prepared substrate
Source: GIZ case study in Cau Rao river park, Quang Binh, Viet Nam

STEP 6
SPREAD SOIL INTO THE HOLES AND PLANT GRASS

- When the pavers have been laid, spread a layer of soil on the surface of the pavement
- Gently rake the soil into the voids of the pavers
- With the pavers filled, add some additional soil and sand and sprinkle grass seeds on the surface
- Water the seeds and continue to water regularly until the seeds have germinated
- Suitable grass species include:
  - Cynodon dactylon (Bermuda)
  - Zoysia japonica
  - Axonopus compressus
  - Bermuda Princess 77

Use of these species increases germination rates and save on monthly pruning and care costs

Figure 14b: Planting grass into the pavers
Source: GIZ case study in Cau Rao river park, Quang Binh, Viet Nam

Source: freepik.com

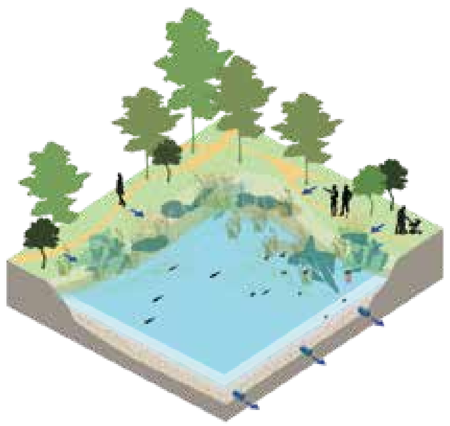
Besides the grass blocks, there are other common types of permeable pavements including porous asphalt, porous concrete, permeable interlocking concrete pavers, plastic reinforcement grids and natural rock pavers. Among these, porous asphalt or porous concrete can be used for slow-traffic roads. Other types can be used for pathways without affecting the pedestrian user experience. Below is a typical cross-section of these various types of permeable pavements.

Figure 15: Six common types of permeable pavements
Source: shutterstock.com, freepik.com

Figure 16: Porous asphalt cross-section
Source: shutterstock.com

4.2.2 BIORETENTION BASINS

The installation of a bioretention basin is another solution. In Viet Nam, there are various plants that can be used in a retention basin, which can green the landscape and filter the water at the same time.



- During construction, avoid excessively compacting soil around the water retention area and accumulating silt around the drainage field. To minimize sediment loading in the treatment area, direct runoff to the water retention area only from areas that are stabilized; always divert construction runoff elsewhere.

- Soil is typically backfilled in layers or 'lifts'. The type of lift will depend upon the nature of the backfill and the compaction equipment that is used.
- Place water retention soil media in 1-foot to 2-foot lifts and compact with minimal pressure until the desired elevation is reached. Some engineers suggest flooding the soil between each lift placement in lieu of compaction.

A vegetated soil lift consists of wrapping 'lifts' of soil in geotextile fabric to form an edge for the stream. Willow stakes can be planted between the 'lifts' and through the top of them. Benefits of vegetated soil lifts include:

- Streambank stability
- Riparian habitat
- Aquatic habitat improvement

Figure 17: An example of a vegetated soil lift
Source: habitatassessment.com

APPLICATIONS AND DESIGN PRINCIPLES

Water retention areas are suitable for a wide range of climatic and geologic situations. Common applications for water retention areas include parking lot islands, median strips, and traffic islands. Water retention is often a feasible "retrofit" that can be accomplished by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. In residential sites, water retention areas are commonly used to deal with rooftop and pavement runoff.

Water retention areas are usually sized (based on soil media void space and ponding area) to capture and improve the water quality (usually between 1 – 2 cm of runoff, depending on local requirements).

Water retention areas are typically designed in layers as follows (from the bottom of the excavation to the surface):

- Impermeable liner (optional)
- Gravel layer (approximately 30 cm) with optional underdrain
- Pea stone layer (approximately 35 cm)
- Water retention soil media composed of 40% sand, 20 - 30% topsoil, 30 - 40% compost (between 60 - 120 cm)
- Fine-shredded hardwood mulch (approximately 7 cm)
- Ponding depth (varies with site conditions; usually between 15 - 22 cm)
- The planting plan typically includes herbaceous perennials and shrubs which can tolerate frequent ponding, saline conditions, and extended dry periods

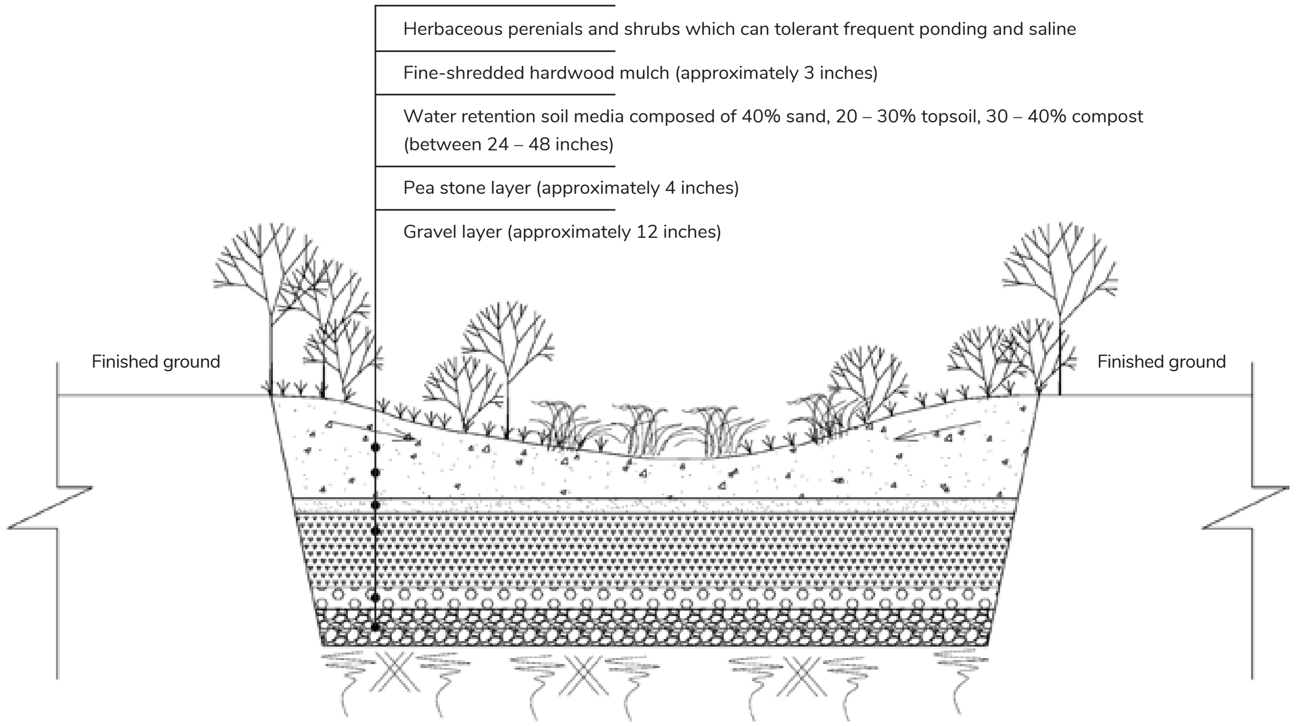


Figure 18: Bioretention basin cross-section (GSI city Details and Specifications)
Source: Redrawn by OMGEVING cv based on Lotus Water (n.d.)

In very permeable soils, water retention areas can be designed as "off-line" treatment structures (no overflow necessary). However, in most circumstances, they are designed as an "on-line" component of a stormwater management system. Ideally, overflow outlets should be located as far as possible from runoff inlets to maximize storage time and treatment within the water retention area. In general, water retention areas should be designed to drain within 72 hours.

PLANTATIONS

The technique of purifying water by growing grass on floating rafts is becoming increasingly popular. The roots of some species, such as water hyacinth, water spinach or other species of reed planted in floating tubs have the ability to decompose and absorb excess nutrients to prevent the growth of algae and the development of unpleasant odours. These roots can also trap and sequester black mud particles and heavy metals, which then sink to the bottom of the basin, thereby clarifying the water. Finally, they can replenish oxygen, restoring the natural balance of the system.

4.2.3 BIOSWALES

Bioswale systems are generally preferred in areas with permeable ground and relatively low groundwater levels. The only construction they require is the digging of a linear depression with slanted walls. Parabolic or trapezoidal shapes are recommended with side slopes no steeper than 3:1.

STEP 1
POSITION THE BIOSWALE

A bioswale should be at least 3 m away from homes, offices or any other buildings. The bioswale should be located on a low point with at least a 1% grade slope from the pavement, parking lot or roof leading from the green space or building.

STEP 2
DETERMINE THE DIMENSIONS OF THE BIOSWALE

Determining the size is one of the most important steps in creating a bioswale. It is recommended to calculate the water ratio, volumes, etc., to properly determine the size of the bioswale.

STEP 3
DIG AND PREPARE THE BASE CONDITION

- After determining the size and location, construction can start by removing some soil.
- This will allow the bioswale to collect the rain, which will feed the plants and ultimately limit pollution, etc. If there is a downspout nearby, it must drain into the bioswale. This might make it necessary to dig a small trench to direct its flow into the swale.
- The bottom of each bioswale is filled with coarse gravel, which facilitates rapid infiltration. The gravel and gabion (a metal cage which serves as a conduit to the gravel layer below), are then wrapped in a permeable geotextile fabric. This fabric allows water to pass through but prevents dirt and sediment from clogging the pore space below.

Figure 19: Creating the base condition
Source: shutterstock.com, stock.adobe.com

STEP 4
SELECT PLANT MATERIALS

- The requirements of this stage will vary from one place to the next. Promoting native plants over invasive species helps to regenerate the natural environment. Before choosing plants, research is needed to ensure that the landscape is repopulated with indigenous plants.
- To safeguard the area, a typical plant mix comprises sedges, grasses, and trees. Sedges and grasses should be employed along the margins of the bioswale to secure the banks, while "pollution eaters" can be planted in the center, where the water collects.

STEP 5
SECURE THE SITE

- Jute netting, native wildflowers, and grass seeds are needed to secure the site. After the planting is done, use jute netting around the bioswale edges to protect the area from erosion. The jute will mitigate erosion and preserve the site's natural slope. Using staples, secure the netting to create a solid foundation.
- After the netting is in place, scatter indigenous wildflower and grass seeds over the area. This promotes native plant growth and helps to restrict the germination of invasive grasses and other weeds.

TECHNICAL SECTION

A simple bioswale is divided into four different layers:

1. The top layer of a bioswale is made up of densely packed vegetation that provides a large surface area for stormwater contact. The swale can filter pollutants better if the grasses are thicker and heavier. Plants with excellent nutrient-absorbing capabilities (ideally native plants) are selected and planted.

2. Underneath the vegetation, an absorbent layer of sand is laid down. It induces the colloids in murky water to aggregate into bigger clumps, making them easier to remove.

3. A layer of gravel, scoria, or baked clay pellets is encased in geotextile beneath that layer. Large voids in these materials allow rainfall to drain away. To keep the layer from becoming blocked by sludge or roots, it is wrapped in geotextile.

4. Below the second layer, there is a perforated drainage pipe. Overflows connected directly to this are added to prevent a bioswale from overflowing its banks during heavy downpours.

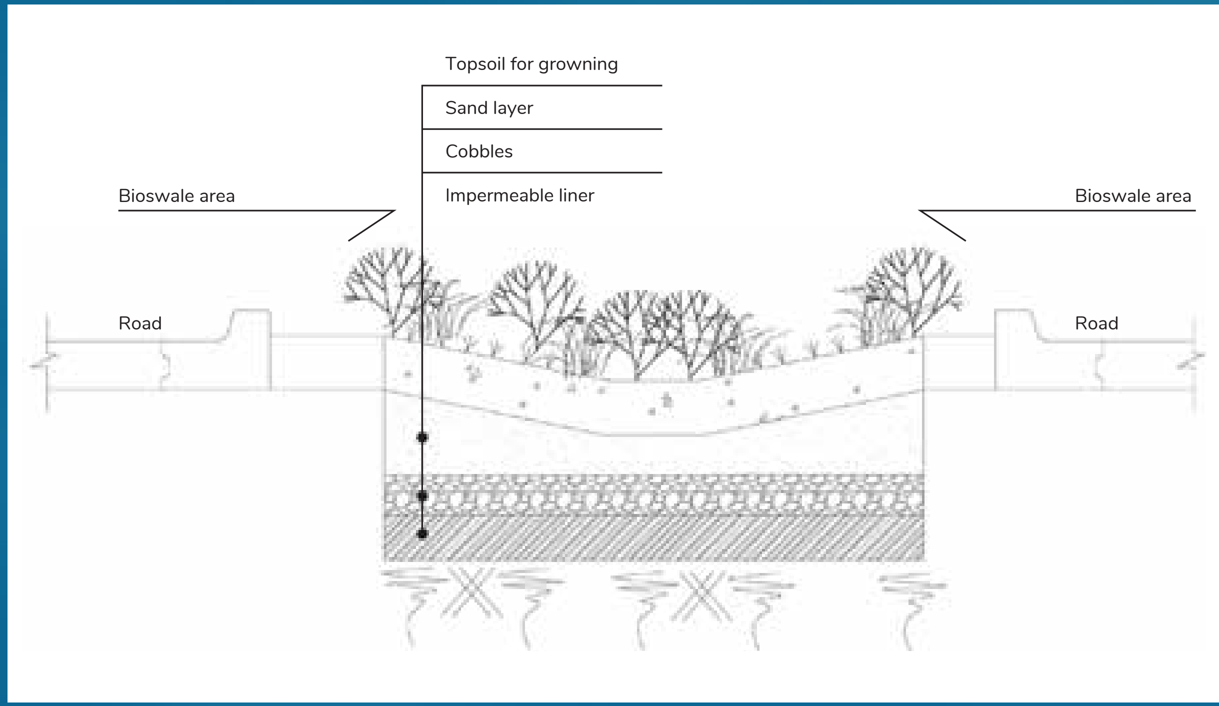
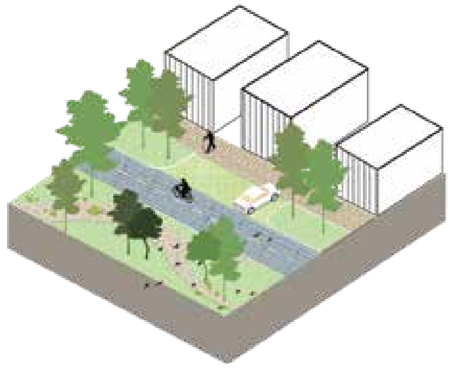


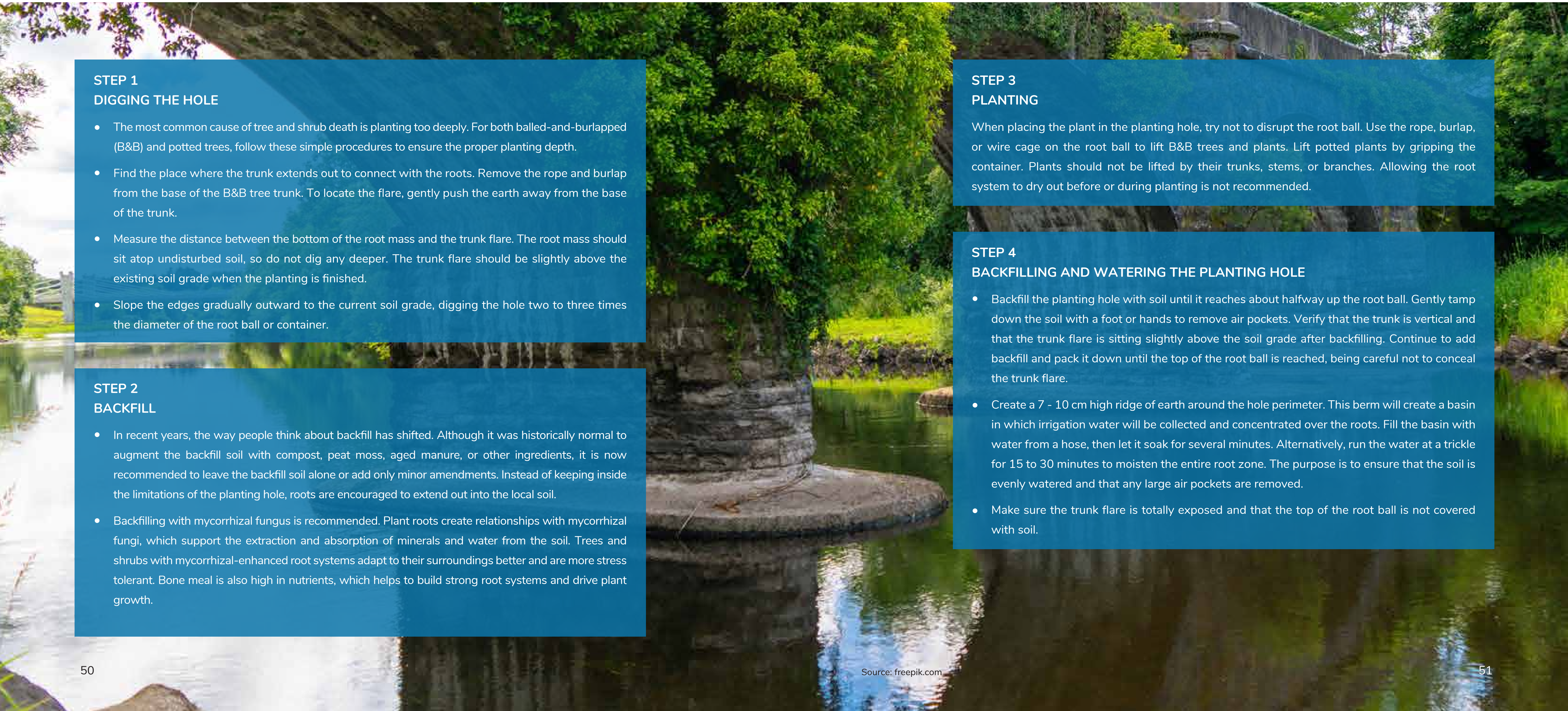
Figure 20: Bioswale cross-section
Source: Redrawn by OMGEVING cv based on Jusic et al (2020)

4.2.4 NATURAL CORRIDORS

Natural corridors (trees and hedges) are planted to serve as a second line of flood defense to existing levees. The area between an existing levee on the riverbank and the new barriers creates recreational land during dry periods and serves to attenuate surface water flow during times of heavy rain.



Regarding the implementation of tree corridors alongside urban roads, one should consider the integration of the existing underground technical infrastructure. The trees should be indigenous to the area and should also require minimal maintenance. Careful consideration of the invasiveness of the root systems of any trees (into existing subterranean infrastructure) should also be given.



STEP 1
DIGGING THE HOLE

- The most common cause of tree and shrub death is planting too deeply. For both balled-and-burlapped (B&B) and potted trees, follow these simple procedures to ensure the proper planting depth.
- Find the place where the trunk extends out to connect with the roots. Remove the rope and burlap from the base of the B&B tree trunk. To locate the flare, gently push the earth away from the base of the trunk.
- Measure the distance between the bottom of the root mass and the trunk flare. The root mass should sit atop undisturbed soil, so do not dig any deeper. The trunk flare should be slightly above the existing soil grade when the planting is finished.
- Slope the edges gradually outward to the current soil grade, digging the hole two to three times the diameter of the root ball or container.

STEP 2
BACKFILL

- In recent years, the way people think about backfill has shifted. Although it was historically normal to augment the backfill soil with compost, peat moss, aged manure, or other ingredients, it is now recommended to leave the backfill soil alone or add only minor amendments. Instead of keeping inside the limitations of the planting hole, roots are encouraged to extend out into the local soil.
- Backfilling with mycorrhizal fungus is recommended. Plant roots create relationships with mycorrhizal fungi, which support the extraction and absorption of minerals and water from the soil. Trees and shrubs with mycorrhizal-enhanced root systems adapt to their surroundings better and are more stress tolerant. Bone meal is also high in nutrients, which helps to build strong root systems and drive plant growth.

STEP 3
PLANTING

When placing the plant in the planting hole, try not to disrupt the root ball. Use the rope, burlap, or wire cage on the root ball to lift B&B trees and plants. Lift potted plants by gripping the container. Plants should not be lifted by their trunks, stems, or branches. Allowing the root system to dry out before or during planting is not recommended.

STEP 4
BACKFILLING AND WATERING THE PLANTING HOLE

- Backfill the planting hole with soil until it reaches about halfway up the root ball. Gently tamp down the soil with a foot or hands to remove air pockets. Verify that the trunk is vertical and that the trunk flare is sitting slightly above the soil grade after backfilling. Continue to add backfill and pack it down until the top of the root ball is reached, being careful not to conceal the trunk flare.
- Create a 7 - 10 cm high ridge of earth around the hole perimeter. This berm will create a basin in which irrigation water will be collected and concentrated over the roots. Fill the basin with water from a hose, then let it soak for several minutes. Alternatively, run the water at a trickle for 15 to 30 minutes to moisten the entire root zone. The purpose is to ensure that the soil is evenly watered and that any large air pockets are removed.
- Make sure the trunk flare is totally exposed and that the top of the root ball is not covered with soil.

Source: freepik.com

STEP 5
MULCHING, STAKING & FERTILIZING

- Cover the entire planting hole with 5 - 8 cm of bark mulch. Mulching conserves water and keeps weeds at bay. Allow the mulch to taper toward the tree's base, but not to touch the trunk.
- It is not always necessary to stake at the time of planting. When deciding whether or not to stake, consider the root-ball stability, trunk size and strength, prevailing wind direction, canopy size and density. If unsure, consult a nursery expert.
- During the first year of growth, fertilizing newly planted trees and shrubs is not recommended.

STEP 6
WATERING

Moisture is essential for the survival of a young tree or shrub. The roots should never be allowed to dry out completely or to become saturated with water. To determine soil moisture, dig a 5 - 10 cm hole just outside the plant root mass and water if the soil is dry. For the first two weeks, inspect and water newly planted shrubs and trees every other day. If less than 2.5cm of rain occurs throughout the week after the first two weeks, limit watering to once a week. Thorough drenching that moistens the soil to the full depth of the root mass is preferable to frequent light waterings.

Figure 21: Maintenance of a green corridor
Source: stock.adobe.com

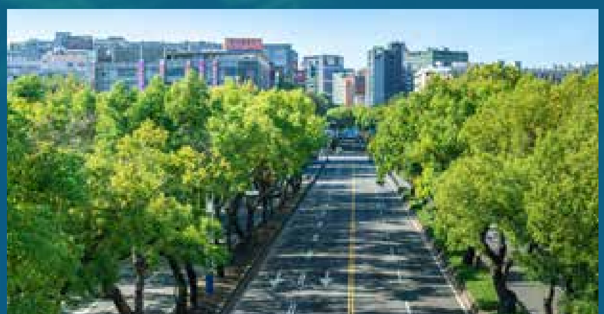


Figure 22: A green corridor in Taiwan
Source: shutterstock.com

Figure 23: Periodical tree watering
Source: freepik.com

Source: freepik.com

4.3 COST OF WATER RETENTION AREAS

In general, the cost of nature-based infrastructure such as water retention areas is roughly 50% cheaper than the traditional grey infrastructure to provide the same service (Micheal T, 2021). However, the exact calculation of the construction cost for water retention areas in the Vietnamese context is complex and depends on various parameters such as the type of water retention, the surface area, etc. Moreover, in the construction cost, a distinction must be made between land-related costs, construction costs and maintenance costs.

Source: freepik.com

From the earlier description of the concept of water retention, it is assumed that water retention interventions are often part of a larger green space or wider (green) infrastructure project. In this sense, the costs are part of a larger construction cost whereby, based on the case study for the river park, a distinction can be made between the total construction cost, the cost for greening, and the specific cost for the construction of water retention infrastructure. The Cau Rao river park case study provides insights into the magnitude of these costs to gain a general overview of expected costs for water retention interventions in the Vietnamese context.

4.3.1 GENERAL PARAMETERS FOR THE CONSTRUCTION COST

CONSTRUCTION AND IMPLEMENTATION COST

Costs of bioretention areas depend on the type of water retention solution installed, the complexity of installation, initial site conditions and characteristics, and labour and material costs. Potential bioretention solutions range from low-cost investments (e.g. detention ponds) to more expensive bioretention solutions (e.g. bioretention basins). Costs associated with protecting, restoring, or creating urban green corridors depend on the size of the green corridor, site conditions, the type and size of trees and other vegetation used, and the underlying labour and material costs.

MAINTENANCE COST

Maintenance costs of water retention areas are also a function of the type and complexity of the water retention solution installed, the types and sizes of trees and vegetation planted, the complexity of planting, local climatic conditions, and labour costs. Maintenance activities may include debris removal, weeding, and pruning.

OTHER COSTS

Apart from the cost of construction and maintenance, there are other costs that should be taken into account. These can be divided into 5 groups: (i) Project management consulting, design, and construction supervision, (ii) Cost of appraisal, verification of investment projects & design verification, (iii) Costs related to contractor selection, (iv) Costs related to audit work, and (v) Redundancy costs. Other costing regulations during the implementation of construction investment projects need to comply with Circular 10/2021/TT-BXD, Circular 12/2021/TT-BXD, Decree 99/2021/ND-CP, Decree 63/2014/ND-CP and relevant current regulations.

4.3.2 GENERAL COST FOR CONSTRUCTION AND MAINTENANCE

The general cost for construction and maintenance per type of water retention is also indicated in the table below:

Table 4: Indicative cost of water retention areas

		Installation cost	Maintenance cost
Permeable pavements	Good	20 - 70 USD/m²	1 - 2% of the construction cost
	Porous asphalt	5 - 10 USD/m²	
	Interlocking pavers	55 - 110 USD/m²	
Bioswales	Swales	15 - 20 USD/m²	Grass swale: 2.5 USD/m²/yr
	Swales bioretention systems including vegetation Swale top 3 - 4 m wide and filter zone 1 m wide	100 - 120 USD/linear meter	Vegetated swale: 9 USD/m²/yr (initial) 1.5 USD/m²/yr (after 5 year)
Bioretention basins	Bioretention filters/Rain gardens	110 - 130 USD/m²	5 - 7% of the construction cost
	Retention/Detention pond	20,000 - 40,000 USD/megaliter	3 - 5% of construction cost
Natural corridor	A study on the cost-benefit performance of street and park trees in 5 US cities from different States estimated the total annual municipal expenditures for tree planting and ongoing maintenance to be from 15 USD to 65 USD per tree.		

Source: Maksimović, Kurian, and Ardakanian (2014)

The above costs should be used for international reference. In the Vietnamese context the figures could change due to the overall lower living cost. Therefore, based on GIZ case study in Quang Binh, it is helpful to have a cost table for water retention facilities for the Vietnamese context.

Table 5: Unit cost per water retention type

No.	Cost description	Price/m² (VND)	Price/m² (USD)
	Construction and implementation		
1	Permeable pavement (Permeable block brick walkway)	260,570	11.39
2	Bioretention basin (Multi-season stage to store water)	295,203	12.91
3	Bioswale/Rain garden	1,115,292	48.77
4	Natural corridor (Landscape green tree)	989,088	43.25

Source: Extrapolated from the GIZ case study

OTHER COSTS

The table below shows other costs with the percentage when compared to the total construction cost.

Table 6: Other costs as a proportion to the construction cost

No.	Cost group	Ratio to construction cost
1	Project management consulting, design, construction supervision	8.61%
2	Cost of appraisal, verification of investment projects & design verification	2.03%
3	Costs related to contractor selection	1.08%
4	Costs related to audit work	1.27%
5	Redundancy costs	5.65%

05

QUANG BINH CASE STUDY

This chapter will describe in detail the case study in Dong Hoi city, Quang Binh province, Viet Nam. This case study is carried out based on GIZ's previous work with EbA measures for Dong Hoi city. GIZ's goal is to mainstream EbA, an essential tool in the response to climate change and to the achievement of the Sustainable Development Goals. The Cau Rao river park is an inspiring example of the four types of water retention areas.

The figure gives a clear image of the development of Cau Rau river park, where four types of water retention areas were applied and integrated, creating a water runoff system based on delay-store-drain principles. Pathways and a playground were installed with permeable pavements to slow down the runoff and allow water infiltration into the soil. The bioswales were installed along the road network, together with natural corridors, to delay and convey the runoff to the river park, where bioretention basins store the stormwater and drain it into the river or drainage system.

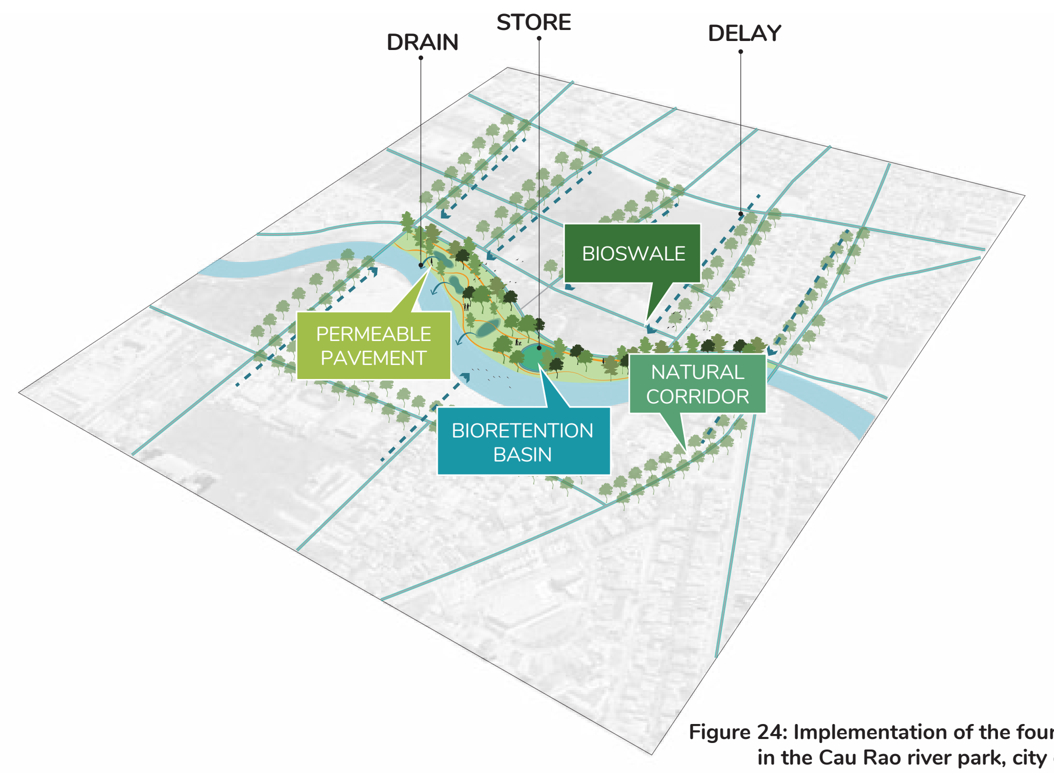


Figure 24: Implementation of the four types of water retention in the Cau Rao river park, city of Dong Hoi, Quang Binh
Source: Graphic based on GIZ study

5.1 PLANNING THE PROJECT

Figure 25: Satellite image of Cau Rao river park
Source: Google map

5.1.1 SITE ASSESSMENT

This chapter will look closely at the first measure implemented in Quang Binh: Cau Rao river park as a practical example for applying the water retention areas in the urban context.

Cau Rao river park site assessment:

- This river park is a buffer zone next to the river.
- Located in the catchment area of the four urban wards and communes, which subsequently contribute to the reduced urban runoff discharge pressure through the creation of open field retention, waterscape recharging, deep infiltration and other sub-components
- Land clearance has been completed.
- Total land area of over 85,000 m^2
- The riverbank has been stabilized with grey-green measures to avoid riverbank erosion.
- There is a strong consensus between the provincial/municipal governments and local communities.

5.1.2 GOAL SETTING

Located on the main floodway, urban flood risk, the park helps to release pressure during heavy rain and protecting the city. Moreover, it aims to reduce heat stress in the core urban zone of Dong Hoi city, improve existing ecosystem health and increase blue-green space for the city. Given the central location, it would benefit at least four urban quarters in Dong Phu ward and improve the overall city's flooding condition.

5.1.3 STAKEHOLDER ENGAGEMENT

GIZ and DONRE were responsible for the overall management of the project implementation in collaboration with other key partners, the provincial Department of Construction (DoC), Dong Hoi city People's Committee, and the contracted designer(s). To simplify, the consortium and stakeholder roles and responsibilities are broken down below based on the three main phases of implementation: design, construction and maintenance.

WATER RETENTION AREAS IN CAU RAO RIVER PARK

IMPLEMENTER (GIZ)

- Allocate funds
- Manage the project and organize bidding procedures
- Collaborate with the beneficiary unit and local authorities
- Select consultants

BENEFICIARY (Dong Hoi city's Public Service Management Unit)

- Receive project support
- Collaborate with the donor to manage the project
- Provide information for site assessment
- Provide inputs and engage in planning, design, monitoring implementation
- Receive training and guidance for operation and maintenance
- Receive hand-over and take responsibility for maintaining the work

LOCAL AUTHORITY

- **Dong Hoi city People's Committee:** Approve the project idea
- **Dong Hoi city Department of Urban Management:** Collaborate to provide information for site assessment and project design; monitor the project implementation
- **Quang Binh Province Department of Construction:** Approve the Project Design and issue the project implementation permit

CONSULTANTS/CONTRACTOR

- **Design consultants:** Conduct site assessment, develop project design and supporting technical documents
- **Design auditing agency:** Appraise the project design and technical documents
- **Construction/Installation contractor:** Construct the project components
- **Monitoring consultant(s):** Monitor the project implementation

Figure 26: Stakeholder map
Source: GIZ case study

Figure 27: Aerial view: landscape design of Cau Rao river park
Source: Graphic based on GIZ study

5.2 INSTALLING THE WATER RETENTION AREAS

The following sections show how four types of water retention areas are installed in Dong Hoi city. In this example, all water retention facilities are total filtration systems, meaning there are no liners and all rainwater is absorbed by the underlying soil.

5.2.1 PERMEABLE PAVEMENT

There are two types of permeable pavements. Porous pavements, such as porous asphalt and concrete, are not popular in Viet Nam. The second type is the permeable pavements in which material blocks are moulded with void spaces. The most common material is the grass block paver, widely used in Viet Nam.

Figure 28 shows the technical cross-sections for the grass blocks installed in the parking lot and playground in Cau Rao river park. They share the same layers with a few variations in the thickness in response to the different above-ground forces.

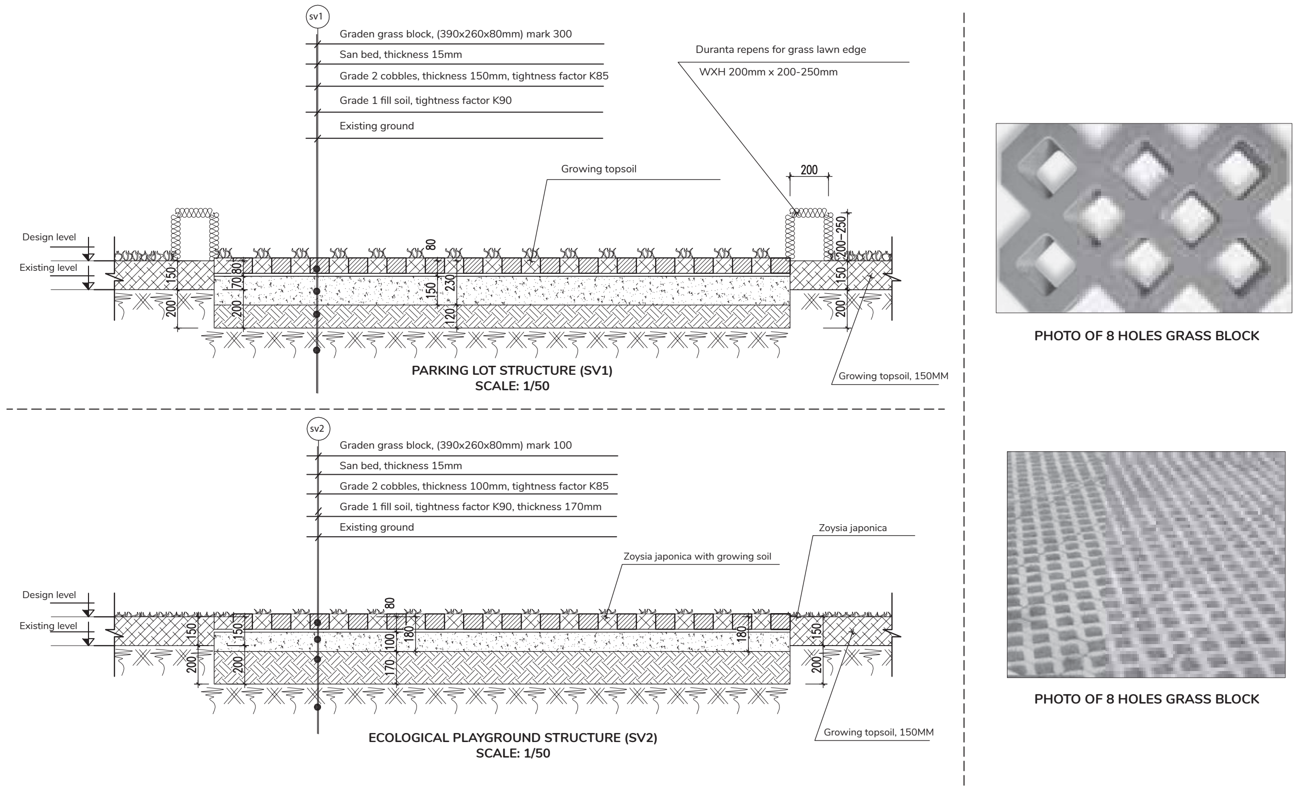


Figure 28: Example from Cau Rao river park: Grass block/Grass concrete section
Source: Graphic based on GIZ study

The other example of permeable pavements is the natural stone path which incorporates voids (100 - 150 mm) on the pathway so that water can drain through.

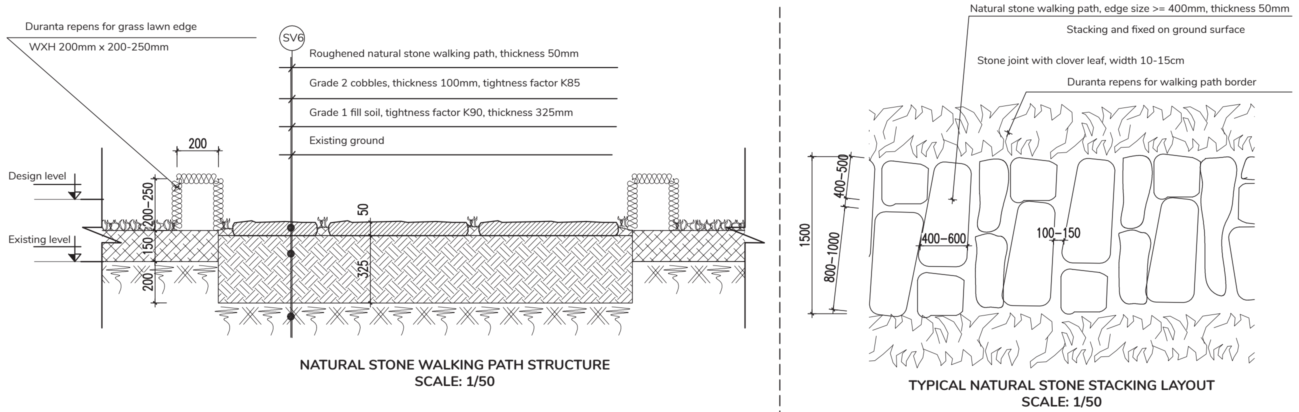


Figure 29: Example from Cau Rao EbA River Park: Natural stone path section
Source: Graphic based on GIZ study

5.2.2 BIORETENTION BASINS

The bioretention basin in Cau Rao river park is a typical 1,500 mm section including geotextile, topsoil and vegetation on top. It has an overflow manhole to control the water level. When it is over 2.15 m, it will drain into the manhole through a grating.

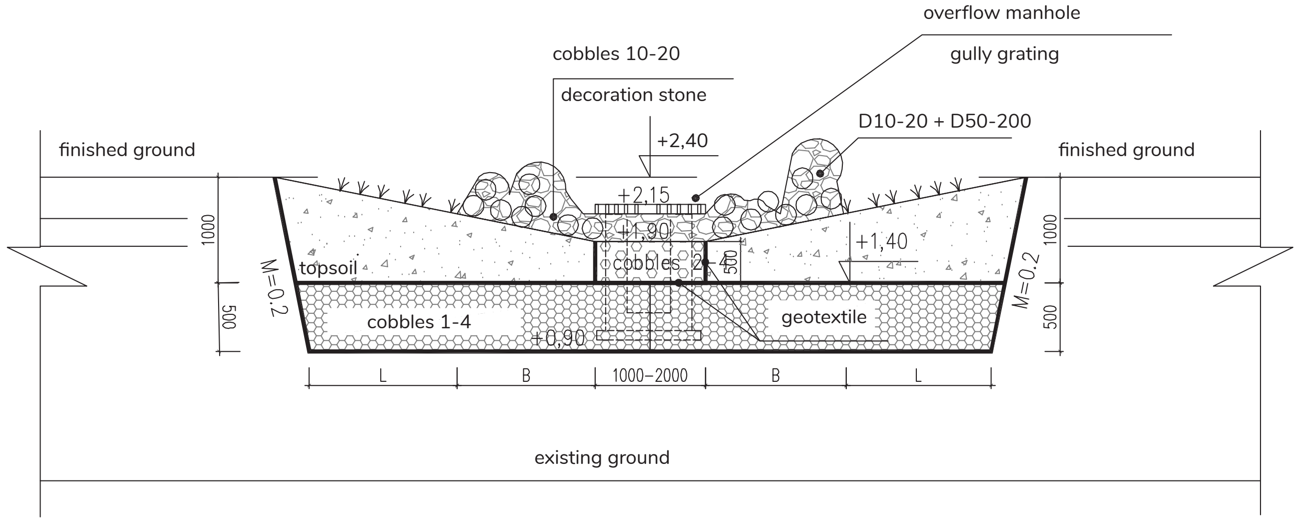


Figure 30: Bioretention filters/Rain garden section in Cau Rao river park
Source: Graphic based on GIZ study

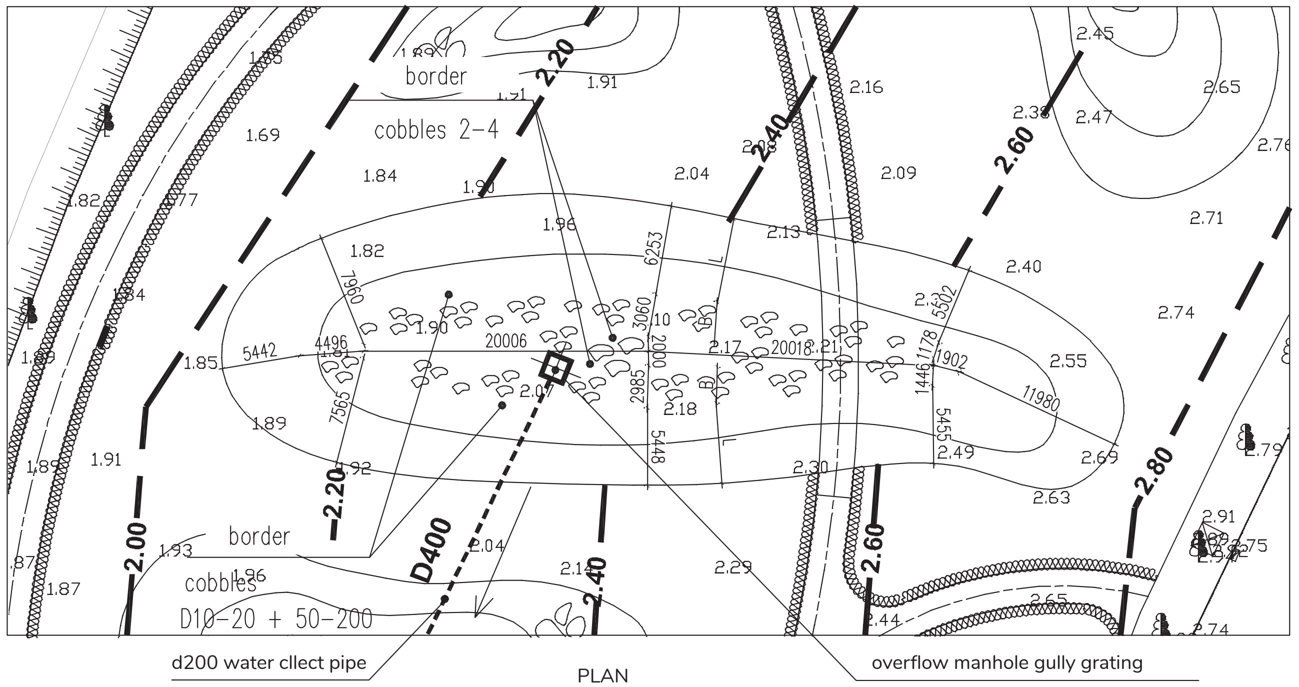


Figure 31: Bioswales/Rain garden plan in Cau Rao river park
Source: Graphic based on GIZ study

5.2.3 BIOSWALES

Three-metre-wide infiltration trenches are designed along the walking path in the project. A 1:5 slope is designed to collect water from the surrounding area, and a 500mm-wide trench is located in the middle with a different cobble size to store the water temporarily and filter runoff before letting it infiltrate the soils beneath.

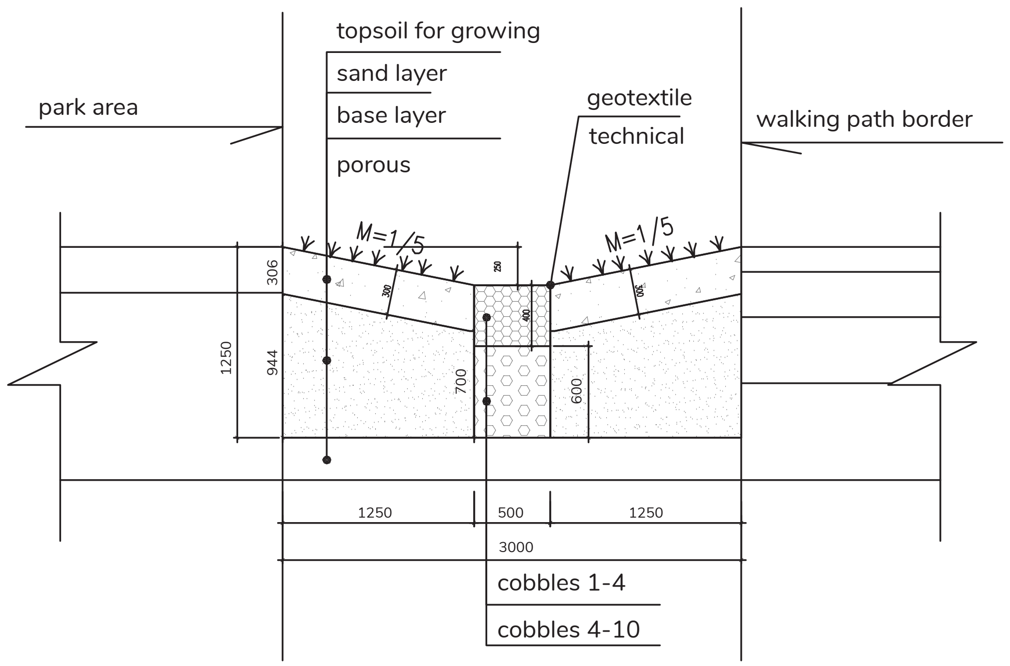


Figure 32: Infiltration trench section in Cau Rao river park
Source: Graphic based on GIZ study

Figure 33 below illustrates the technical cross-section of a bioswale in the Cau Rao river park. The system is lined with a perforated HDPE pipe to convey the excess runoff into the site drainage system.

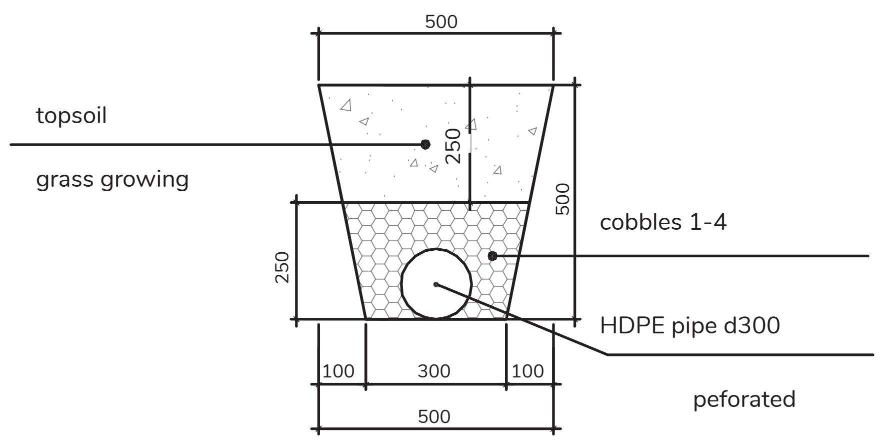


Figure 33: Bioswale section in Cau Rao river park
Source: Graphic based on GIZ study

5.2.4 NATURAL CORRIDOR

The figure below shows the trees and plants chosen for Cau Rao river park. They not only provide green spaces but have other specific benefits. Swietenia macrophylla for example, can absorb air pollutants, providing cleaner air. Moreover, it is very resilient to inundation owing to its special root structure. Another example, Arachis pintoi, a forage species, contributes nutrients and enhances soil fertility.


Swietenia Macrophylla


Tabebuia Rosea


Cassia Fistula


Bucida Molinetii


Melaleuca Citrina


Dalbergia Tonkinensis


Cluster Of Century Plant


Shaped Whistling Pine Tree


Mango Tree


Bougainvillea Bush


Iroxa Shrub


Seasonal Flowers


Axonopus Compressus


Zoysia Japonica


Arachis Pintoi


Reed


Cyperaceae

Figure 34: Examples of plant materials from Cau Rao river park: Native trees, shrubs and grasses
Source: Graphic based on GIZ study

The section below shows the minimum required soil depth for thriving plants. Grasses require a minimum of 150 mm topsoil above the existing ground. This depth should be a minimum of 600 mm for shrubs and 1,000 mm for trees.

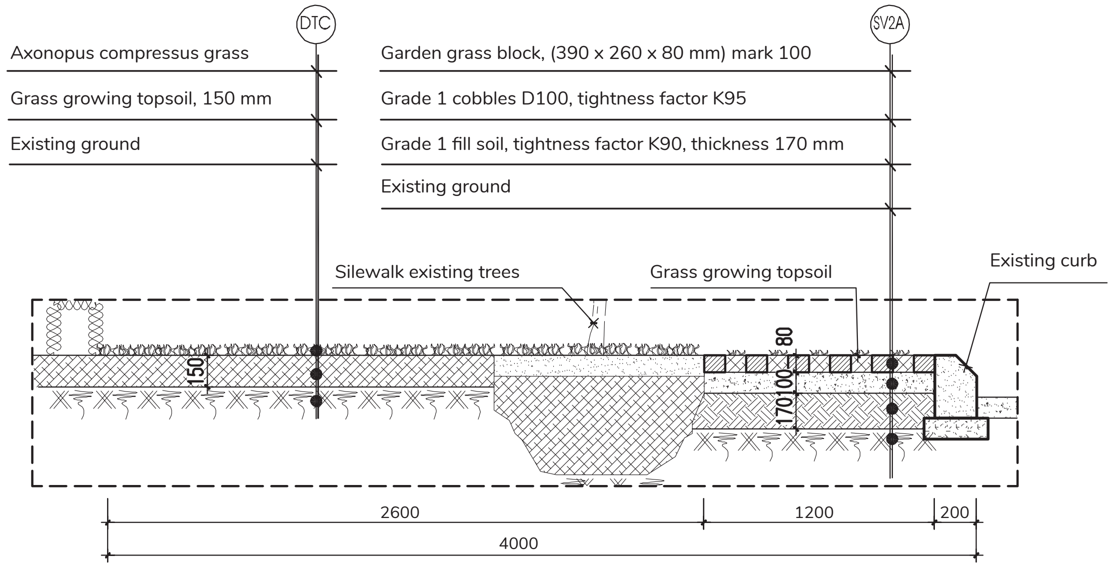


Figure 35: Example from Cau Rao river park: Section of plantation and sidewalk
Source: Graphic based on GIZ study

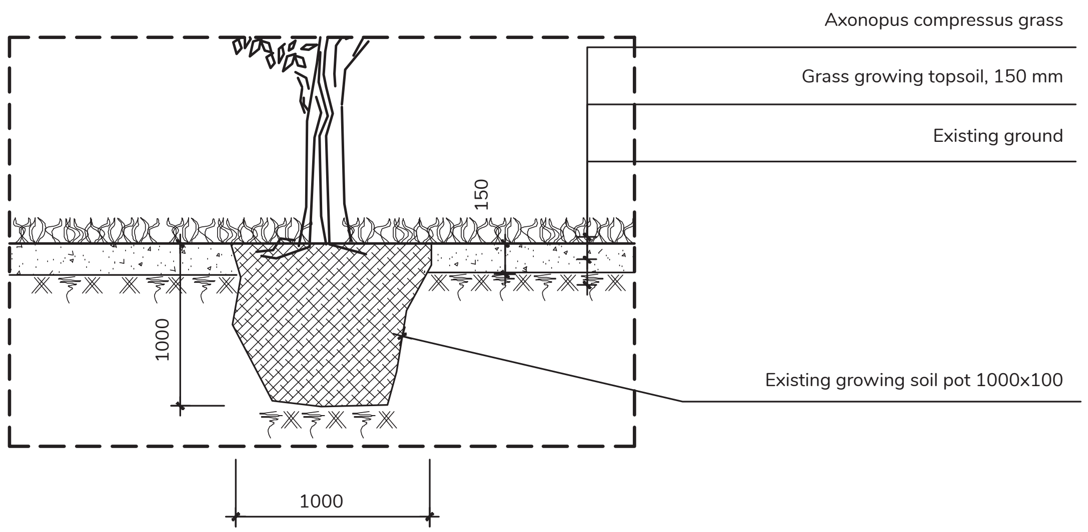


Figure 36: Example from Cau Rao river park: Detail of tree pot
Source: Graphic based on GIZ study

5.3 MAINTENANCE

The example of the Cau Rao river park in Quang Binh demonstrates that it is beneficial when a local entity takes lead responsibility for the maintenance of water retention projects. The ‘Dong Hoi Green Tree and Park Centre’ will be the entity that operates and maintains the river park due to its mandates assigned by the Dong Hoi city People's Committee. This centre will be responsible for ensuring the health of the natural elements of the project and for replacing the dead/damaged elements, as needed. The centre has a four-hectare nursery of native and locally adapted trees/vegetation species which is used for park development and maintenance in Dong Hoi city.

The nursery will be used to replace dead trees and add native or locally adapted species as part of the park maintenance.

Upkeep of the footpaths in the park also falls under the responsibility of the centre.

5.4 IMPLEMENTATION COSTS

The general cost of construction considered the water retention areas as part of a larger green infrastructure project, the Cau Rao river park. The example of the river park gives insight into the cost in the Vietnamese market. The total land area of the park implemented is 49,000m². For this larger park entity, a cost of approximately 232,000 VND/m² or 2,320,000,000 VND/hectare is assumed, or the equivalent of 10.16 USD/m² or 101,600 USD/hectare.

CONSTRUCTION COST

Table 7: Summary of construction costs: Pilot water retention project, Cau Rao river park, Quang Binh

No.	Work item	Pre-tax Value (VND)	Value (USD)	Price/m² (VND)	Price/m² (USD)	Percentage (%)
I	**Construction cost**	**10,833,349,000**	**474,211**	**127,451**	**5.58**	**95.2%**
1	Site grading	89,163,000	3,903	1,049	0.05	0.8%
2	Grass and plants	4,077,016,483	178,464	47,965	2.10	35.8%
3	Garden and multi-season stage	4,186,136,029	183,241	49,249	2.16	36.8%
4	Water supply system	280,501,335	12,278	3,300	0.14	2.5%
5	Retention and drainage system	790,119,611	34,586	9,296	0.41	6.9%
6	Power supply and lighting system	1,410,412,777	61,738	16,593	0.73	12.4%
II	**Contingency cost**	**541,667,000**	**23,711**	**6,373**	**0.28**	**4.8%**
	Total cost	**11,375,016,000**	**497,921**	**133,824**	**5.86**	**100.0%**

CONSTRUCTION COST PER PARK COMPONENT

For the construction cost per park component, a distinction is made between the green construction with plants and lawns and the cost for water drainage and retention.

CONSTRUCTION COSTS: PLANTS AND LAWN

The green construction cost is approximately 91,500 VND/m² or 915,000,000 VND/hectare, the equivalent of 4 USD/m² or 40,000 USD/hectare.

Table 8: Summary of construction cost estimates: Pilot water retention project, Cau Rao river park, Quang Binh. Item 3: Plants & Lawn

No.	Cost description	Cost value (VND)	Price/m²
I	CONSTRUCTION DIRECT COST		
1	Material cost	2,862,779,002	33,680
	+ According to materials quantity summary	2,862,779,002	33,680
2	Labor cost	633,060,156	7,448
	+ According to materials quantity summary	633,060,156	7,448
3	Construction equipment cost	59,331,587	698
	+ According to materials quantity summary	59,331,587	698
	Total of construction direct cost	**3,555,170,745**	**41,826**
II	INDIRECT COST		
1	General cost	195,534,391	2,300
2	Site office for construction management	42,662,049	502
3	Unforeseen cost	71,103,415	837
	Total of indirect cost	**309,299,855**	**3,639**
III	PRE-CALCULATED INCOME TAX	**212,545,883**	**2,501**
IV	VALUE ADDED TAX	**4,077,016,483**	**47,965**
V	AFTER-TAX CONSTRUCTION COSTS	**407,701,648**	**4,796**
	ROUNDED VALUE	**4,484,718,000**	**52,761**

Source: pxhere.com

CONSTRUCTION COST: WATER DRAINAGE AND RETENTION

The construction cost for water drainage and retention is approximately 17,800 VND/m² or 178,000,000 VND/hectare, the equivalent of 0.78 USD/m² or 7,800 USD/hectare.

Table 9: Summary of construction cost estimates: Piloting water retention measure for Cau Rao river park, Quang Binh. Item 5: Water drainage and retention

No.	Cost description	Cost value (VND)	Price/m²
I	CONSTRUCTION DIRECT COST		
1	Material cost	535,521,470	10,929
	+ According to materials quantity summary	535,521,470	10,929
2	Labour cost	80,284,135	1,638
	+ According to materials quantity summary	80,284,135	1,638
3	Construction equipment cost	73,181,094	1,493
	+ According to materials quantity summary	73,181,094	1,493
	Total of construction direct cost	**688,986,699**	**14,061**
II	INDIRECT COST		
1	General cost	37,894,268	773
2	Site office for construction management	8,267,840	169
3	Unforeseen cost	13,779,734	281
	Total of indirect cost	**59,941,842**	**1,223**
III	PRE-CALCULATED INCOME TAX	**41,191,070**	**841**
	Pre-tax construction costs	790,119,611	16,125
IV	VALUE ADDED TAX	**79,011,961**	**1,612**
V	AFTER-TAX CONSTRUCTION COSTS	**869,131,572**	**17,737**
	ROUNDED VALUE	**869,132,000**	**17,737**

06

Conclusions:

IMPLICATIONS FOR THE IMPLEMENTATION OF WATER RETENTION AREAS IN VIET NAM

Water retention areas at the city and neighbourhood scale support flood management by providing technical and environmental benefits, but also provide social benefits on both levels. The ecological and landscape structure of the city or the neighbourhood is key to identifying the appropriate water retention type and location. A comprehensive study of several specific characteristics, such as topography, hydrology, climate, and ecology, will inform an overall understanding of the water drainage system.

Due to the complexity and flexibility of water retention applications, it is important in new urban developments to consider the most appropriate water retention system for the project at an early stage of the design process to ensure compliance with local legal regulations. The construction cost of well-designed green infrastructure is also cheaper and more effective than grey infrastructure where maintenance is a key concern.

This then allows the creation of a well-functioning water retention network, able to meet the challenges posed by flooding. Depending on the characteristics of the project, the scale and the context, the following water retention types can be installed in combination or individually:

- Bioretention basins to collect and store water in lower urban areas
- Bioswale networks or green corridors to redirect and channel the water into the main water storage areas
- Urban green corridors along rivers/coastline to protect inland areas from inundation due to high tides
- Natural corridors to increase infiltration capacity

Source: freepik.com

SIPA | SUPPORT TO VIET NAM FOR THE IMPLEMENTATION OF THE PARIS AGREEMENT

6.1 OPPORTUNITIES

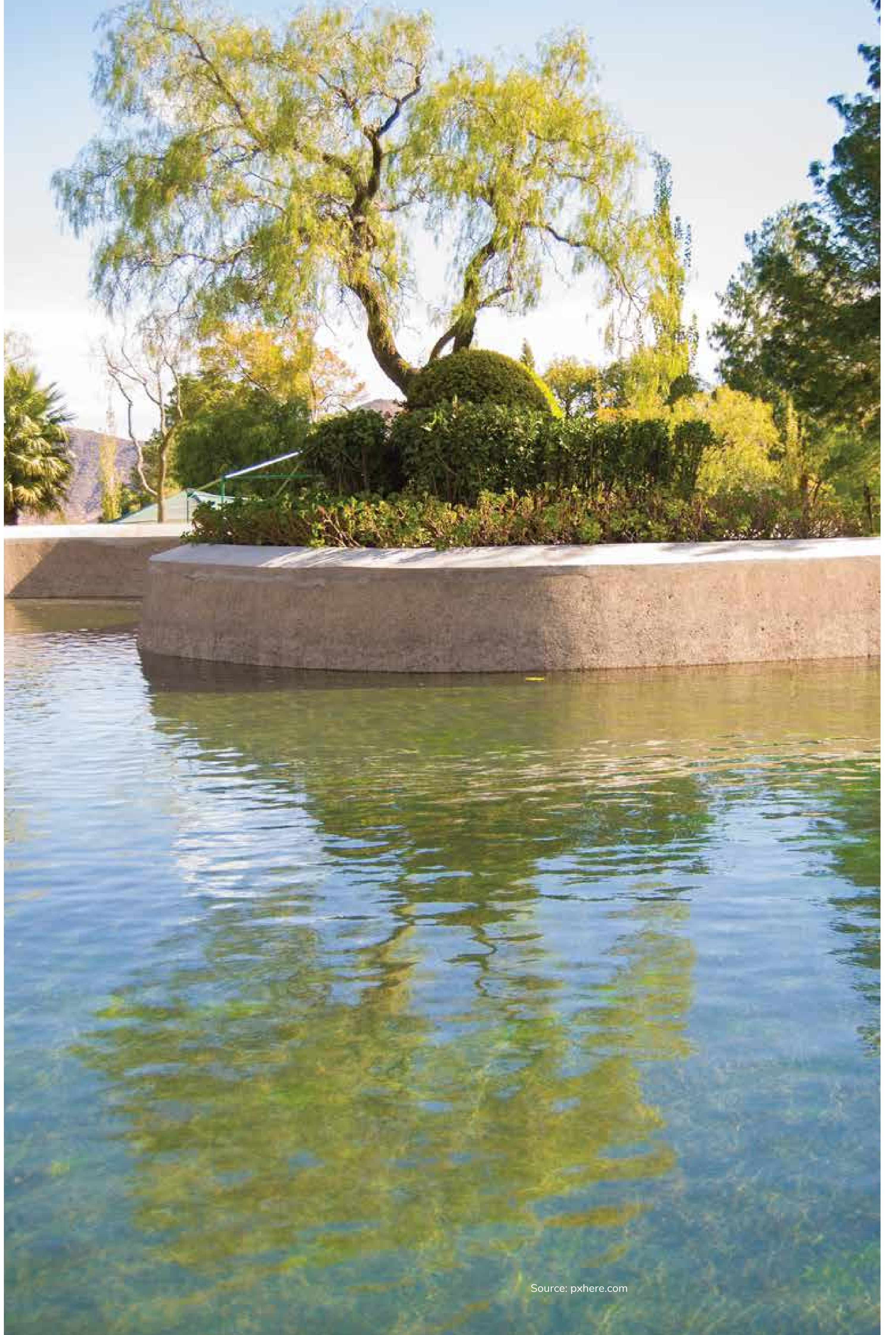
The promotion of water retention areas for medium-sized coastal cities provides the following opportunities:

- Supporting the implementation of the national government's commitment to combat global climate change and promote sustainable development
- Making use of an expanding market for water retention technologies and options for different levels from neighbourhood to city
- Importing foreign technical assistance, broadening the knowledge of urban managers, investors and the general public

6.2 CHALLENGES

The implementation of water retention areas in urban areas of medium-sized coastal cities must take into account the following challenges:

- Limited governance structures (regulations, standards, etc.) and public policy incentives at both national and local levels
- Insufficiently tangible benefits as economic benefits are not immediately clear
- Lack of knowledge of water retention areas and their benefits
- Technical issues and maintenance
- Insufficient financial capacity and bankable funding schemes
- Insufficient public awareness of such projects and their benefits
- Lack of comprehensive database of technologies, products and manufacturers



Source: pxhere.com

6.3 RECOMMENDATIONS IN THE CASE OF VIET NAM

The incorporation of green infrastructure is necessary to address the increasing impacts of climate change on cities. This type of adaptation needs to be implemented according to rigorous standards and technical guidance. Even more importantly, cities should primarily focus on conserving existing nature-based systems. As more investment projects will be conducted in the future, blue-green spaces in urban areas are at significant risk of being destroyed. Thus, it is a matter of great importance to maintain green infrastructure in cities for them to remain resilient in the face of worsening climate change. Finally, decisions regarding infrastructure projects should seriously consider the integration of water retention areas.

To implement effective water retention areas in Viet Nam, the following recommendations are being put forward:

- Promote public policies (i.e. legal obligations, taxation incentives, financing support, etc.) and appropriate strategies at national and local levels
- Stimulate knowledge sharing about the technical, environmental and social benefits
- Identify key components of the available financing mechanisms to design attractive incentive programmes
- Incorporate water retention areas in public projects to provide tangible examples and motivate private investors
- Develop a database of technologies, products and service providers for each geographical and climate region
- Promote enabling market conditions for green infrastructure industries
- Enhance collaboration between scientists, policymakers and practitioners to promote knowledge transfer and implementation
- Encourage the participation of urban residents to guarantee the successful implementation of water retention areas

With these recommendations, governments, developers and citizens can work together towards creating the livable and sustainable cities of tomorrow in which water retention areas and other nature-based solutions contribute to a resilient urban green system.

07

REFERENCES

City of Winnipeg (2022). Retention Ponds. Available at: http://winnipeg.ca/waterandwaste/drainageFlooding/ponds.stm

Drake, J., Bradford, A., & Marsalek, J. (2013). Review of environmental performance of permeable pavement systems: State of the knowledge. Water Quality Research Journal of Canada, 48. https://doi.org/10.2166/wqrjc2013.055

Ellis, J. B., Shutes, R. B. E., and Revitt, M. D., (2003). Linkages and Interactions between Wetland Design Elements, Constructed Wetlands and Links with Sustainable Drainage Systems.

Falak, A. (2020, October 20). Grasscrete: Sustainable Paving Systems | Types, Advantages & Installation. Available at: https://gharpedia.com/blog/grasscrete-paving-systems-types-advantages-installation/

Hunt, W. F., Lord, B., Loh, B., & Sia, A. (2015). Plant Selection for Bioretention Systems and Stormwater Treatment Practices. Springer. Truy cập tại https://doi.org/10.1007/978-981-287-245-6

Iberdrola (2022). Green corridors, how to take care of the environment in cities. Available at: https://www.iberdrola.com/-sustainability/green-corridor

Jusic, S., Hadžić, E., and Milisic, H. (2020). Urban Stormwater Management – New Technologies. In Algorithms and Architectures for Parallel Processing (pp. 790–797). Available at: https://doi.org/10.1007/978-3-030-18072-0_90

Lead Local Flood Authorities of the South East of England. (2013). Water. People. Places. A guide to master planning sustainable drainage into developments. Available at: https://www.westsussex.gov.uk/media/2270/suds_design_guidance.pdf

Leber, B. (2015). Stormwater Basins: How Detention and Retention Ponds Work. Available at: https://info.wesslerengineering.com/blog/stormwater-basins-detention-retention-ponds

Long Island Sound Study. (2019). The Sidewalk Gardens That are Making Water Cleaner in New Haven. Available at: https://longislandsoundstudy.net/2019/11/new-haven-bioswales/

Lotus Water. (n.d.). GSI City Details and Specifications. Available at: https://www.lotuswater.com/gsi-city-details-and-specifications

Kellagher, R. (2021). Delivering benefits through evidences, Rainfall runoff management for developments.

Maksimovic, Č., Kurian, M. and Ardakanian, R. (2015) Rethinking Infrastructure Design for multi-use water servicesCham: Springer

Michael. T. (2021). Turning infrastructure green offers huge savings on top of climate benefits. Available at: https://www.reuters.com/business/cop/turning-infrastructure-green-offers-huge-savings-top-climate-benefits-2021-10-25

NACTO (2013). Urban Street Design Guide. Available at: https://nacto.org/publication/urban-street-design-guide/street-design-elements/stormwater-management/bioswales/

Spaan, K., Van der Meijs, M., & van Nood, M. (2019). Consulting report for guidelines, principles and process for a resilient Zhuhai. EC-Link. Available at: https://www.wereldwaternet.nl/contentassets/5997e6c3285e4834a0bb2643db64a021/20190508_zhuhai-consulting-report_def.pdf

Sprouse, C. E., Hoover, C., Obritsch, O., & Thomazin, H. (2020). Advancing Pervious Pavements through Nomenclature, Standards, and Holistic Green Design. Sustainability, 12(18), 7422. Available at: https://doi.org/10.3390/su12187422

STEP. (2013). Technical Brief, Performance Evaluation of Permeable Pavements, Low Impact Development Series. Toronto and Region Conservation Authority. Available at: https://sustainabletechnologies.ca/

USACE (2021). International Guidelines on Natural and Nature-Based Features for Flood Risk Management. Available at: https://ewn.erdc.dren.mil/?page_id=4351

Verburg, R. W., Hennen, W. H. G. J., Puister, L. F., Michels, R., & Duijvendijk, K. van. (2017). Estimating costs of nature management in the European Union: Exploration modelling for PBL's Nature Outlook. Wageningen University & Research, Statutory Research Tasks Unit for Nature and the Environment.

Woods Ballard, B., Wilson, S., Udale-Clarke, H., Illman, S., Scott, T., Ashley, R., & Kellagher, R. (2015). The SuDS Manual. CIRIA.

World Bank (2020). Climate risk country profile Vietnam. Available at: https://www.adb.org/sites/default/files/publication/653596/climate-risk-country-profile-viet-nam.pdf

Source: pxhere.com

Support to Viet Nam for the
Implementation of the Paris Agreement (VN-SIPA)

Unit 031, 3rd Floor, Coco Building
14 Thuy Khue, Tay Ho District
Hanoi, Viet Nam
Phone : (+84) 0243.2373.110
Email : office.sipa@giz.de