CAMBODIA CLIMATE CHANGE ALLIANCE

Implemented by:

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Cambodia Resilient Urban Green Infrastructure Economic and Policy Analysis Study

Final Report

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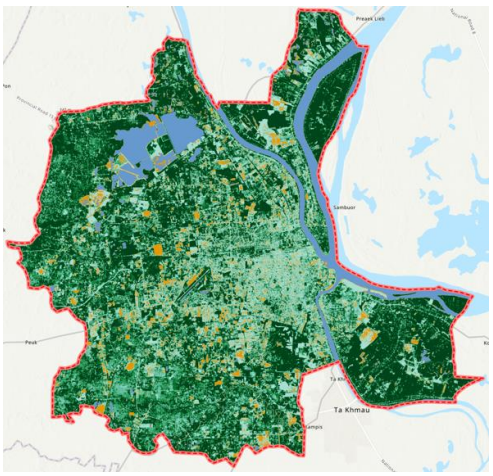

CLIMATE SCRUTINY

Green Infrastructure consultancy

CSIP
CENTER FOR STRATEGY AND INNOVATION POLICY

Cambodia Resilient Urban Green Infrastructure

Economic and Policy Analysis Study

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Abbreviations

ADB Asian Development Bank
BAU Business as Usual
BCR Benefit Cost Ratio
BREEAM Building Research Establishment Environmental Assessment Method
CBA Cost Benefit Analysis
CCCA Cambodia Climate Change Alliance
CSIP Centre for Strategy and Innovation Policy
EPA Environment Protection Agency (US)
FOLU Forestry and Land Use Change
GGGI Global Green Growth Institute
GI Green Infrastructure
GIC Green Infrastructure Consultancy
GIS Geographic Information System
ha hectares
JICA Japanese International Cooperation Agency
LEED Leadership in Energy & Environmental Design
LID Low Impact Development
m^2 square meters
m^3 cubic meters
MAFF Ministry of Agriculture, Forestry and Fisheries
MCA Multi-Criteria Analysis
MEF Ministry of Economy and Finance
MH Phnom Penh Municipal Hall
MISTI Ministry of Industry, Science, Technology and Innovation
MLMUPC Ministry of Land Management, Urban Planning and Construction
MME Ministry of Mines and Energy
MoE Ministry of Environment
MEYS Ministry of Education, Youth & Sport
MoT Ministry of Tourism
NDVI Normalised Difference Vegetation Index
MPWT Ministry of Public Works and Transport
NbS Nature Based Solutions
NCDD National Committee for Sub-National Democratic Development
NCSD National Council for Sustainable Development
NPPF National Planning Policy Framework (UK)
NPV Net Present Value
O&M Operation and Maintenance
UGI Urban Green Infrastructure
UNDP United Nations Development Programme
UNGI Urban Neighbourhood Green Index

Summary

This report describes the results of a study into the economics and policy framework for resilient urban green infrastructure (GI) in Cambodia, with a focus on Phnom Penh. The study was undertaken for the Ministry of Economy and Finance, the Cambodian Climate Change Alliance and the United Nations Development Programme.

The study consulted a panel of 15 residents, workers and entrepreneurs in Phnom Penh and 13 key informants, including employees in government, private developers, research and development agencies. The consultation revealed a strong awareness and interest of urban GI and especially of the value of trees and gardens. There was also good awareness of green roofs and green walls, rivers and rainwater harvesting, although verges were considered less important. The interviews discussed a wide range of risks facing residents and found that roughly half these risks were reduced by GI. The biggest challenges to the expansion of GI were seen as arising from: pressure on land coming from population growth; support in the form of financing, monitoring and technical capacity; and the need for clearer regulations, guidelines and incentives. The consultation showed good awareness of the benefits from GI, with particular interest in reduced pollution, cooling, better living environments (both indoor and outdoor) and mental health. Benefits associated with water quality, carbon emissions, energy efficiency, physical activity and noise were recognised, but were considered a lower priority.

Satellite images were analysed to produce a map of the distribution of vegetation in Phnom Penh. This map, presented in chapter 2, shows a wide variation in vegetation cover and stresses the importance of having a clear baseline from which to plan and monitor progress. Chapter 2 also refers to international research that suggests that Phnom Penh has amongst the lowest levels of GI in Southeast Asia.

The study reviewed about 40 papers on the costs and benefits of urban GI, including several that were themselves reviews of other studies. This showed that there were wide variations in the way in which the costs and benefits of GI were reported, which make it difficult to compare the results and consider their relevance to Cambodia. Nevertheless, this report proposes ‘typical values’ for the unit costs and unit benefits of each type of GI asset. This analysis suggests that all GI assets have a Benefit Cost Ratio (BCR) of greater than 2 and that trees and verges are particularly positive, with BCRs of more than 8. The analysis also breaks down the benefits into 7 types and shows that: cooling benefits are mainly associated with green roofs, green walls and trees; flood risk reduction is mainly associated with trees, parks and verges; improvement in quality of life is mainly associated with trees, parks and verges; and increased inward investment is generated by all types of GI.

The values for unit costs and benefits should not be considered as accurate estimates for specific GI investments. They are, however, reasonable mid-range estimates that can be used to assess total potential costs and benefits of a programme of GI investment. There are also suitable as ‘yardsticks’ that may guide the collection of site-specific information and act as comparators for a national library of evidence and experience.

The analysis defines a 10 year 'moderate scenario’ for the expansion of GI in Phnom Penh, which involves increasing GI cover by 2400 hectares, which is about 3.5% of the total administrative area. The scenario includes a mixture of high value investment in green roofs and green walls, which may be required in more central districts, as well as trees, parks and gardens which are appropriate across the whole city. Annual investment costs are USD 35.5m, of which about two thirds are funded by the private sector. Operation and maintenance (O&M) costs grow as GI assets expand and reach USD 16.1m from year 10 onwards, with the private sector again covering about two thirds.

Annual benefits grow to about USD 250m from year 10 onwards, of which about 29% are associated with cooling and another 29% from improvements in quality of life, including health and well-being. Salaries and profits from increased investment account for a further 20.5% of the benefits and flood protection for 16.3%. Other benefits are small. The relative importance of benefits indicated by the literature review is roughly in line with that indicated by the consultation with Phnom Penh residents and key informants, with two exceptions: the consultation suggested that reduced air pollution and carbon sequestration are more important than suggested in the literature. This may be explained by the relatively high levels of air pollution in Phnom Penh and by the recent increase in public awareness about the seriousness of risks associated with climate change.

Public revenue will increase as a result of: taxes on salaries and profits arising from inward investment in enterprises attracted by GI; tax on landlords' profits from charging higher rents; and an increase in Tax on Immovable Property in line with higher property values near GI assets. The increase in total public revenue is slightly higher than the increase in O&M costs for public GI assets. For the private sector, increased profits are nearly double the costs of O&M. The majority of the benefits from GI are experienced by residents and workers in the city in the form of non-market benefits which do not directly affect GDP but will have a strong indirect impact on GDP, especially through increased labour productivity and reduced loss, damage and repairs arising from flooding.

An indicative financing scenario is proposed for the moderate scenario which includes 9 types of finance. Grants, mainly from bilateral donors, are considered most appropriate for technical work on policies and capacity. Public financing is required for about one third of the expenditure and would come approximately equally from: the conventional budget; loans from multilateral development banks; and innovative mechanisms (e.g., green bonds, impact/KPI bonds, taxes and user charges). Private sector financing comes primarily from conventional investment (e.g., from invested profits and bank borrowing). However, development finance institutions and innovative solutions (including green bonds and corporate social responsibility) become increasingly important over the 10 years. There is also a modest but increasing role for public private partnerships, where the public and private sector both provide investment and share the benefits. Philanthropy provides a small contribution in monetary terms, but may be important in encouraging innovation.

If the moderate scenario were expanded by 50%, it would put Phnom Penh amongst the best cities in Southeast Asia, in terms of urban GI. A less ambitious scenario would be wasteful because the substantial investment in policies and capacity would not deliver the full potential benefits from urban GI that should be possible with the moderate scenario.

To inform the potential future interest in urban GI in Cambodia, the report describes 10 examples of GI initiatives in SE Asia, includes cases in Thailand, Indonesia, Vietnam, Malaysia and Singapore. Whilst some of these examples involve levels of investment that would not be directly relevant to Phnom Penh, many of the principles used in other SE Asian countries are directly applicable in Cambodia.

The report concludes with recommendations for a three phase Phnom Penh Masterplan for the expansion of GI. The first phase focuses on preparation, including: the design of new policies; the studies necessary to establish a baseline and define zones for more detailed plans; and some capacity building and networking. The second phase focuses on the piloting on new policies and of new financing sources. The final phase concentrates on investment, with growing access to innovative financing.

1 Introduction and background

1.1 Introduction

Aim and objectives. This report aims to generate evidence, economic analysis and concrete policy recommendations to integrate green infrastructure (GI) in urban development in Cambodia. The target audience for this document is local administrators and municipal officials, policy makers, residential, commercial and industrial development project developers, business, the public, academics, non-governmental organizations and national and international development partners. Insights should help to prioritize and assess urban GI in Phnom Penh, with relevant insights for other cities across Cambodia and across Southeast Asia.

The objectives the study are as follows:

1. to diagnose the current status of urban GI as well as demand for urban GI in Cambodia.
2. to analyse costs and benefits and other relevant analysis for potential urban GI initiatives in residential and commercial areas under baseline and GI scenarios.
3. to review current GI policies in Cambodia and international best practices and provide policy options to the Ministry of Economy and Finance (MEF) and other relevant government institutions aiming at promoting GI, including measures for the development of a supportive ecosystem along with financing approaches.

The study is being led by the Cambodia Climate Change Alliance (CCCA) with strong interest from the General Department of Policy of MEF and with the support of the regional UNDP project on the Governance of Climate Finance. Technical support is provided by a team of consultants, including Dourng Kakada and Seng Kimty from the Centre for Strategy and Innovation Policy (CSIP) in Cambodia, Kit Nicholson from Climate Scrutiny, Gary Grant from Green Infrastructure Consultancy (GIC) and Jessica Thorn from the University of St Andrews and University of Cape Town.

Impetus for this study. The Cambodia government is increasingly cognizant of the need to address growing climatic risks in urban centres. Cambodia is home to 16 million people in Southeast Asia, with the Mekong River extending through the country and approximately 80% of the population living along low lying regions along the river (UNEP, 2019). Recent rapid economic and population growth nationally has led to substantial development in the last two decade. This trend is expected to continue in the coming decades. In 2017, 21% of the population resided in urban centres, which is expected to increase to 36% by 2050 (MEF, 2021). Phnom Penh is home to about 2.1m people with an annual growth rate of 3.2 % from 2008-2019, including around 250,000 informal settlers. It is the fastest growing city in Cambodia and is expected to grow to 3m by 2035 (Phnom Penh Municipality, 2012; World Population Review, 2021).

Concurrently, climate change is resulting in increasing flash and river flooding. Dry seasons are getting drier, leading to droughts and increased temperatures and resulting in growing urban heat island effects, crop failure and damaged infrastructure. For instance, between 1st of September and 18th of October 2021, Cambodia experienced heavy rainfall resulting flooding in five provinces, affecting 28,468 households and inundating houses, roads, schools and health centres (Humanitarian Response Forum, 2021).

In view of this climate-urban-environment nexus, the government of Cambodia is facing the policy question of how to adapt to and mitigate climate change, while meeting growing urban population growth and economic demands and ensuring biodiversity conservation, poverty reduction, social inclusion and quality of life. Urban GI emphasizes nature-based solutions and land use planning where open spaces and natural areas help to manage urban storm water, flood risk improve water quality

and reduce the urban heat island effect and greenhouse gas (GHG) emissions. The COVID19 pandemic, has further highlighted the important role that open space in cities has in improving residents' mental and physical health and wellbeing and stimulating "building back better".

Yet, little is known about the role of GI in residential, commercial and industrial development projects in the context of Phnom Penh. There is also little knowledge about the fiscal and national policy instruments that have the potential to scale GI for low carbon development and climate resilience in Cambodia, a gap which this report aims to address.

Implications. Insights have relevance to future master planning in Cambodia, including on subjects covered by the following existing plans:

- the 2008 Strategic National Action Plan for Disaster Risk Reduction
- the 2013 National Policy on Green Growth
- the 2015 Fifth National Report to the UN Convention of Biological Diversity
- the 2018 Green Infrastructure Guide
- the Phnom Penh Green City Strategic Plan 2017-2026
- the 2018 Long Term Strategy for Carbon Neutrality
- the Phnom Penh Sustainable City Plan (2018-2030)
- the Strategic Framework and Programs for Economic Recovery in the Context of Living with Covid-19 in a New Normal 2021-2023
- the advancement of the Sustainable Development Goals 1 (no poverty), 2 (zero hunger), 6 (clean water and sanitation), 11 (sustainable cities), 13 (climate action) and 15 (life on land)

1.2 Definition and typology of green infrastructure assets

Green infrastructure is often referred to as multi-functional green space that provides sustainable drainage, carbon storage, cooling in urban centres, reduce storm water runoff, encourage active travel, mental and physical wellbeing, attract investment and overall adapt and mitigate to climate change. The extent to which GI provides these benefits depends on how it is designed and maintained, the quality and maturity of vegetation that is involved, along with other financial, policy, land, behavioural and governance considerations.

While some agencies (e.g., the Organisation for Economic Cooperation and Development and Asian Development Bank) adopt a broader interpretation of GI that extends to transport and utilities (e.g., water, waste and energy), this study focuses on the typology of GI assets presented in Table 1 and covers public spaces, gardens and buildings – specifically public and private gardens, ponds, but also street trees, green roofs and green walls, verges, swales and channelised rivers and streams.

Table 1 Typology of GI assets, benefits and institutional responsibilities

Type	Description	Benefits	Comments	Institutions
Green roof				
Green roof (extensive)	Vegetated roof, low maintenance, not irrigated, shallow growing medium	Cooling (shade, evaporation), source control for surface water. Biodiversity	A locally appropriate approach to be developed, using local materials, substrate and planting. New build and retrofit	MLUPC MH
Green roof (intensive) = roof garden	Vegetated roof garden. High maintenance, irrigated, deep growing medium. Also terraces, balconies.	Amenity, cooling, source control for surface water. Food.	Mainly new build homes	MLMUPC MH
Green wall				
Green wall (intensive)	Modules or pockets. High maintenance, Irrigated	Amenity, cooling	Expensive, but potentially cost-effective for commercial centres	MLMUPC MH

Green wall (extensive) = climbing plants	Climbing plants trained against trellis. Low maintenance	Amenity, cooling, food, biodiversity	Can be trained over mesh to make green 'roof'	MLMUPC MH
Trees				
Street trees	Conventional street trees	Cooling, amenity biodiversity, carbon sequestration	List of species used can be diversified. Use more native species for biodiversity benefits	MH MOE
Street trees (blue)	Tree with pit designed to receive surface water	Cooling, surface water reduction, amenity biodiversity, carbon sequestration	Perhaps a tropical version of Stockholm tree pit to be developed?[i]	MH MOE MLMUPC
Miyawaki forest	Tiny forest of densely planted native trees	Amenity, biodiversity, carbon sequestration	Engages the public – boosts biodiversity [ii]	MH MOE MLMUPC
Park and garden				
Rain garden	Planted area designed to receive surface water runoff	Surface water management, biodiversity, amenity	A new type which would need promotion	MH MPWT MLMUPC
Public park or garden	Publicly accessible garden/park with trees, lawns, planted beds. Could include some home gardens if providing public benefit	Amenity, cooling	Emphasis on ornamentation. Can be modified to increase ecosystem services and biodiversity. Too much topiary, paving and not enough trees in parks (e.g., Wat Botum Park)	MH MLMUPC
Private garden	Garden within compound. Trees. Often potted plants.	Cooling, amenity, food	More planting could be encouraged	MH MLMUPC
Ponds	Ornamental or aquaculture	Surface water storage, biodiversity, amenity	Could be improved for biodiversity, amenity	MH MOE
Verge				
Highway verge	Bermudagrass lawn	Amenity	Could be planted with trees, shrubs or swales, rain gardens added	MPWT MH
Swale	Channel designed to convey surface water	Surface water management, biodiversity	A new type that may need promotion	MPWT MH
Channelised rivers/streams	Straightened and lined watercourse	Amenity, drainage	Can be improved for amenity and biodiversity by softening banks, removing trash, Water quality improved with swales, rain gardens.[iii]	MPWT MH

Source: Adapted for Cambodia from a table developed by Thorn et al 2021, presented in Annex 2.

There are important societal benefits and ecosystem services (e.g., heat mitigation) where synergies leverage the multifunctionality of GI, as listed in Table 1. Developed economies have experienced challenges in urban development, notably through the use of centralized drainage systems that reduce water retention services. Developing countries have the opportunity to 'leapfrog' developed countries and apply more advanced GI practices, especially around water management (Rogers et al. 2019). Concurrently, there are several challenges to mainstreaming GI. These relate, amongst others, to design, performance and maintenance challenges, weak governance, and siloed management, with path dependency or resistance to change and inadequate financial resources, socio-economic barriers and inclusive access to GI, perceptions of ecosystem disservices, cultural barriers, climate change, legal and institutional, land use changes and spatial trade-offs among other challenges (e.g., see Thorn et al 2021 and Section 6.3).

1.3 Green infrastructure initiatives in Cambodia

National Policy on Green Growth. There has been a longstanding interest in green growth in Cambodia, including the *National Policy on Green Growth* approved by the Council of Ministers in 2013, which stressed the importance of balanced economic, social and environmental development,

with a particular focus on water, food security, forest conservation, renewable energy and energy efficiency.

Recovery Strategy. The recently approved Strategic Framework and Programme to Restore and Put Cambodia's Economy Back to the Growth Path in the Context of Living with COVID-19 in a New Normal 2021-2023, prioritizes several regulations and implementation such as enforcement of building-code, guidance principles and certificate of green building, green public procurement implementation and eco-labelling. The recovery strategy takes a broad approach to green recovery, as summarised in Table 2 and includes clear commitment to the narrow definition of urban GI in the second action.

Table 2 Green features of the recovery strategy

Action	Institution Responsible
Promoting the development of local economy, especially in agriculture, agro-industry, handicraft and eco-tourism (e.g., with support for infrastructure, financial resources and incentive policy measures)	- Ministry of Environment - Ministry of Tourism - Ministry of Economy and Finance
Promoting green urbanization, sustainable cities and green park (e.g., with enforcement of building-codes, guidance principles and certificate of green building and public-private partnership)	- Ministry of Land Management, Urban Planning and Construction - City-Province Administration - Ministry of Economy and Finance - Ministry of Environment
Encouraging state-owned financial institutions (e.g., rural development bank and Cambodia SME bank) and private financial institutions to increase green financing	- Rural Development Bank - Cambodia SME Bank - Ministry of Economy and Finance
Promoting the introduction and implementation of a national energy efficiency policy and recycled energy consumption in the master plan of energy sector development 2020-2040	- Ministry of Mines and Energy - Ministry of Environment
Further promoting sustainable consumption and production through green public procurement, eco-labelling, recycling, roadmap for sustainable consumption and production, strengthening of construction management, production of energy from waste and waste processing and extended producer responsibility	- Ministry of Mines and Energy - National Council for Sustainable Development - Ministry of Environment - General Department of Customs and Excise in MEF
Further promoting sustainable consumption and production by promoting green public procurement and the implementation of eco-labelling, strengthening of waste management and encouraging of investment in waste processing	- Ministry of Environment - Ministry of Economy and Finance

Public-private partnership. The Government approved a new law on Public-Private Partnerships (PPP) in late November 2021, which will assist in supporting PPP options for urban GI. The law provides the roles of competent institutions, forms of payment, state guarantees, the rights and obligations of contracting parties and project operation management procedures. The Strategic Framework and Programme to Restore and Put Cambodia's Economy Back to the Growth Path in the Context of Living with COVID-19 in a New Normal 2021-2023, encourages the PPP as one of the financing mechanisms for GI investment and for the promotion of green recovery.

Building and planning regulations. There are some existing policies and regulations that can be used to promote urban GI. In particular, the Sub-Decree No. 43 on Urbanization of the Capital City, Towns and Urban Areas regulates land use in new construction, limiting the footprint of buildings are provide space for trees and gardens. The Construction Code specifies building standards and could be revised to include requirements or guidance on GI. Sub-Decree No. 42 of the same law protects pavements and requires public rights of way to be maintained but includes no mention of GI. As a results, sidewalks are heavily paved and, despite the decrees, are heavily used for parking.

Much of the interest in green growth in Cambodia has focused on low carbon growth and growth in sectors that contribute to economic, social and environmental resilience to risks, especially related to climate change. The Global Green Growth Institute (GGGI) has identified green growth priorities to include resilient agriculture and infrastructure, as well as the energy and waste sectors.

Cambodia has been a pioneer in the integration of climate change into planning and policy, being amongst the five countries participating in the first Climate Public Expenditure and Institutional Reviews (CPEIRs) and one of the first countries to understand a Climate Change Financing Framework and apply a Climate Economic Growth Impact Model. Cambodia has participated fully in UNFCCC reporting, including in the preparation of Nationally Determined Contributions and GHG reporting. A Long-Term Strategy for Carbon Neutrality (LTS4CN) was recently approved.

Green Urban Development Programme. Urban GI initiatives have included the Green Urban Development Programme, implemented with support from GGGI and the Phnom Penh Sustainable City Plan 2018-2030, which covered: urban planning and vulnerability; energy; transport; the built environment; manufacturing; waste and public space (GGGI, 2018). The Plan includes recommendations for zoning land use and defining protected areas, which would help to support the expansion of GI. The Plan also includes recommendations for improved public participation in urban planning, which would help to ensure that the public benefits gained from GI were considered in urban planning.

The plan includes recommendations directly relating to GI, including the following.

- New construction projects should dedicate green corridors and adhere to green building standards.
- The law on urbanisation is enforced more effectively, with regards to providing space for green and permeable surfaces.
- Public parks, gardens and corridors should be expanded significantly.
- Some public areas are redesigned to provide more shade, biodiversity and permeable surfaces.

Build4People. Another GI initiative in Cambodia is the Build4People research programme, which has been operational since late 2017 and has six workstreams: behavioural change; sustainable building; sustainable neighbourhoods; urban green; urban climate; and sustainable urban transformation[1]. The experience from SE Asia reviewed in chapter 6 suggest that the GI in the region often suffers from a lack of evidence about the effectiveness of GI initiatives and inexperience with participation and public engagement. The Build4People programme will provide address these challenges and provide valuable research results for the preparation and management of an expansion in GI in Phnom Penh.

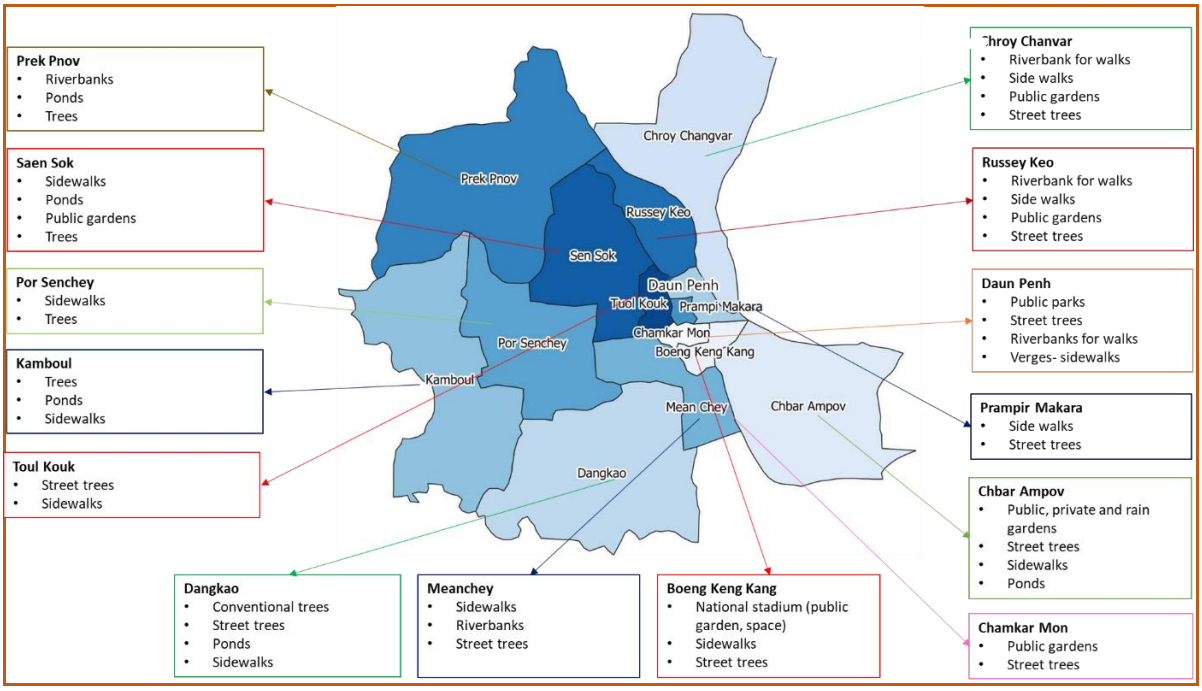
[1] https://build4people.org/work-packages/

2 Green infrastructure assets in Phnom Penh

This chapter describes the main GI assets in Phnom Penh. Three maps are presented: the first describes the main types of assets, as observed by the authors; the second presents an index of vegetation based on satellite imagery; and the third shows the level of vegetation in Phnom Penh compared with other cities in South and Southeast Asia.

Figure 1 presents a simple map of the key GI assets in Phnom Penh and describes the main GI assets in each district, based on the experience of the team.

Figure 1 Map of key GI assets in Phnom Penh based on survey



Source: Authors' observations

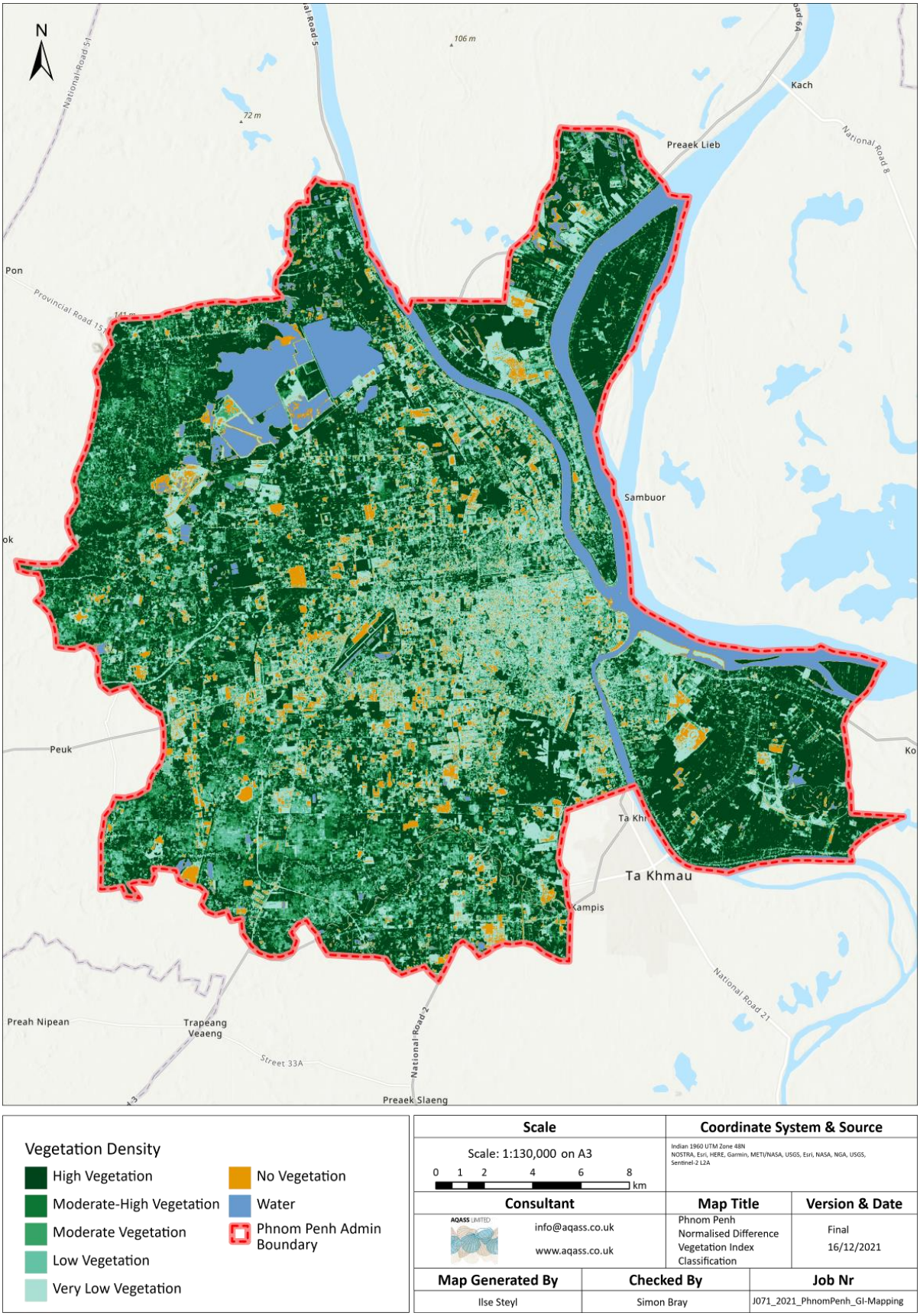
Observed distribution of GI assets in terms of NDVI in Phnom Penh. A more detailed baseline map of the current distribution of vegetation is presented Figure 2. Results were classified using Normalised Difference Vegetation Index (NDVI), which is an index for quantifying green vegetation and a measure of the state of vegetation health, based on how plants reflect light at certain wavelengths. To correct for soil background signals and atmospheric effects, the data were also classified using the Enhanced Vegetation Index (EVI). The indices used give an indication of the different levels of vegetation cover but does not differentiate between different land uses or vegetation type. To generate this map data used was from SENTINEL-2 - which is a European wide-swath, high-resolution, multi-spectral imaging mission and which carries an optical instrument payload that samples 13 spectral bands: four bands at 10m, six bands at 20m and three bands at 60m spatial resolution[2]. The orbital swath width is 290 km. An image with relatively low cloud cover from 4th July 2021 was used.

Results show there is a wide variation of vegetation index within the administrative boundaries of the city. There is an inner city in which vegetation is limited. At the other extreme, there are several zones of high vegetation index, with significant agricultural activity. The boundaries of the zones are not clear, but the inner-city accounts for perhaps 10% of the total city area and is mainly in the four central districts. The more agricultural areas account for about 20% of the city and are mainly in Chroy Chanvar in the northeast and Chbar Ampov and Noriv in the southeast. The remaining 70% (mainly in

[2] (https://sentinel.esa.int/web/sentinel/missions/sentinel-2/overview

Prek Pnov, Por Senchey and Dangkao, to the north, west and south of the centre) is mixed, with a gradual tendency to have increased vegetation cover further from the centre.

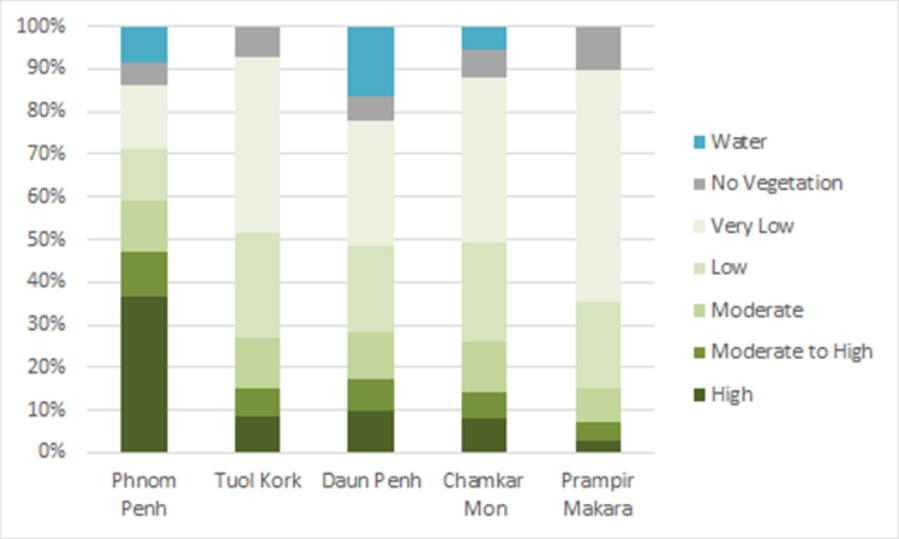
Figure 2 Normalized Difference Vegetation Index density map for Phnom Penh



Source: produced for the report by Dr Ilse Steyl, AQASS Ltd

Figure 3 shows that, when comparing NDVI across the four central districts (*khan*) of Phnom Penh, NDVI density is lowest in Prampir Makara, but similar in the other three districts, with the two highest density categories together accounting for 15% and 18% of total area.

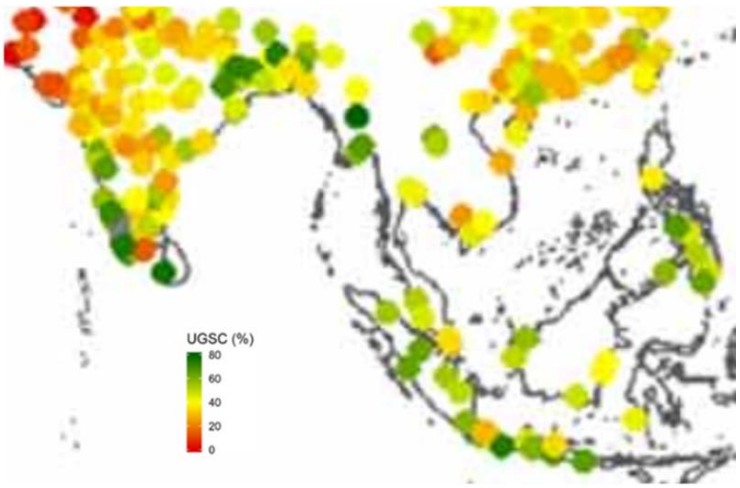
Figure 3 Percentage land with NDVI level in the central districts of Phnom Penh



Source: produced for the report by Dr Ilse Steyl, AQASS Ltd.
Note: columns 2-5 represent the four central districts of the city, while column one is for all districts within the administrative boundary of the city.

Comparison of urban green space coverage in Phnom Penh to Southeast Asian cities. When comparing Phnom Penh to other cities in South and Southeast Asia (Figure 4), Phnom Penh has a lower urban green space coverage and is more comparable with many cities in South China and Northern India. To compare Urban Green Space Coverage (UGSC), the increased quality and availability of satellite imagery make it possible to compare different cities. Yet, this is constrained by the need for consistency of how boundaries of the city are defined. A recent study did this for 1039 global cities (Huang et al 2021). The Huang et al study attempted to resolve this by using a standard algorithm that defined the city boundary according to zones of continuous built-up areas and not administrative boundaries. Applying this approach to Phnom Penh suggested that the continuously built-up area of the city is about double the area of the central four districts and 10% of the total administrative area. But the implications of this in each city will depend on the shape of settlement patterns. For example, the inability of Phnom Penh to expand to the east may have led to a denser central built-up zone.

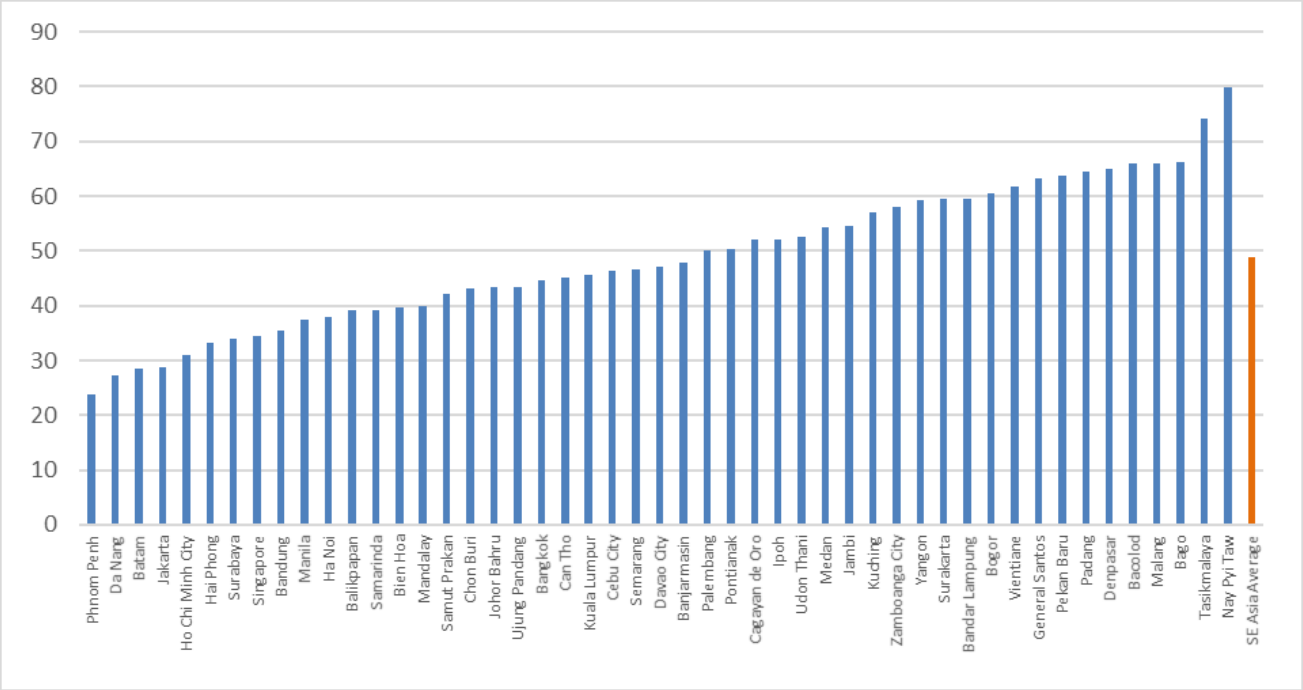
Figure 4 Map of urban green space coverage in South and Southeast Asia



Source: Huang et al 2021

Figure 5 shows that Phnom Penh has a UGSC of 24%, which is amongst the lowest in Southeast Asia and compares with an average of 49% for the region.

Figure 5 Urban green space coverage in Southeast Asia



Source: (Huang, 2021)

It is not possible to compare directly the evidence on the NDVI in Figure 3 and the UGSC in Figure 5. However, a rough assessment of the likely UGSC corresponding to the various UGSC categories suggests that the area of the city covered in the Huang et al. (2021) study is substantially larger than the four inner city districts but substantially smaller than the full administrative boundary.

Perceived changes in GI assets according to key informants. The key informants interviewed for this report expressed the following views on the existing use of GI in Phnom Penh. GI has continued to grow in Phnom Penh especially in private housing developments, malls and cafeterias. Phnom Penh municipality have plans for constructing additional public parks and gardens in new development areas of the city. Existing parks and gardens continue to improve with more green content in parks, including more grass and trees. However, GI understanding is still limited and there is a lack of support regulations such as green building code/standards. There are also challenges on drainage system and traffic jams. The space in the centre of Phnom Penh is limited which could be a potential challenge for GI activities in the future.

Perceived changes in GI assets according to the public panel. The public panel observed a growth in hard infrastructure development and a decline in farming with homeowners to little space for horticulture in their yards. There has also been a growth in water pollution, the amount of solid waste increased significantly and increased traffic. Urban GI in Phnom Penh and public areas is still not enough. It is rare to see kind of green roofs and green walls in cities, areas for shade and cooling, creating public spaces to bring the family to relax stress and exercise, while making the city beautiful. Yet, there has been some positive change, with the Royal Government considering the development of resources and the environment more carefully, with GI incorporated into new developments for a better life and to grow businesses. Reasons for these changes related to the fact that currently Cambodia is developing rapidly; road infrastructure or other structures (both public and private) are

changing rapidly; growing land demand to increase the economy; population growth; and a lack of public awareness of the benefits of GI.

Implications. These results provide a starting point from which to make decisions about possible zoning of the city to facilitate the implementation of a GI Masterplan. However, further detailed analyses and comparisons are needed, including a detailed baseline survey, where GI is classified and quantified, including an urban tree survey, space availability and the feasibility of GI installation compared to or in combination with other assets. and UGI in Phnom Penh is compared to other cities in more detail. This will depend on the availability of quality satellite imagery.

3 Cambodian opinions on green infrastructure

This chapter describes the results of two surveys conducted to obtain the opinions of a panel of residents and a group of key informants who are professionally engaged in fields that relate to urban GI. The consultation provided evidence to assess the extent to which a programme of expanded GI will meet with support from the residents of Phnom Penh and from the people who would be involved in implementing the programme.

Objectives. The consultation meetings aimed to assess the status of urban infrastructure as well as demand for resilient and green urban infrastructure development in Cambodia, with a focus on Phnom Penh as a case study. Objectives of the interviews were to:

- Collect opinions on the status of urban GI in Phnom Penh,
- Evaluate the demand and benefits derived from GI initiatives,
- Evaluate current risks and the role of nature-based solutions in responding to the risk of disasters,
- Assess changes in the status of GI and reasons for these changes and
- Evaluate current initiatives to maintain, restore and upgrade urban GI.

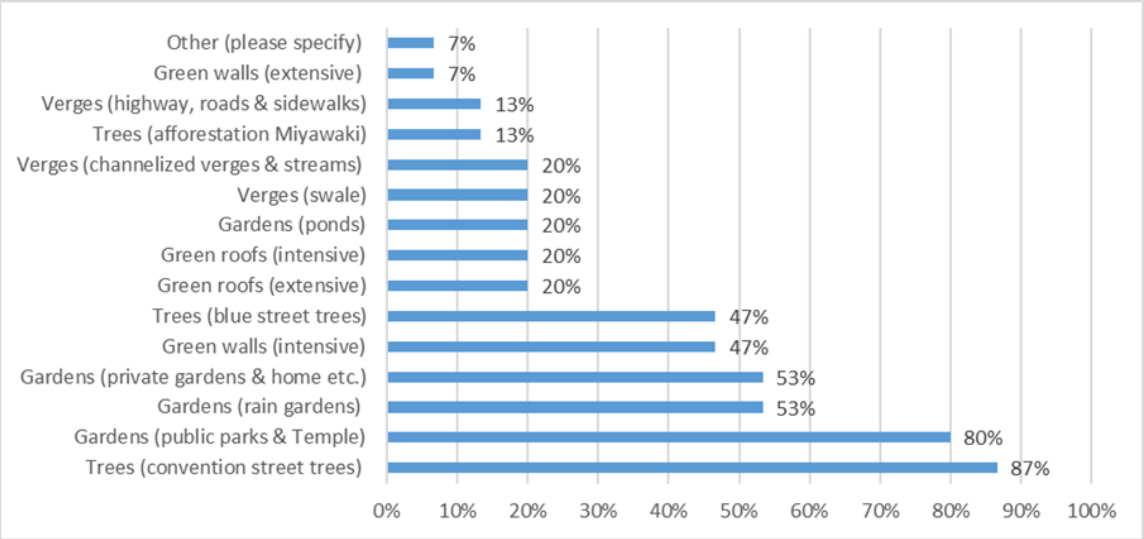
See Annex 3 for the semi-structured questionnaire used in the consultations.

Interviews. Interviews were conducted remotely, due to Covid 19 restrictions in place during the consultation, in Khmer or English by three interviewees with voluntary participation and informed consent. Two types of consultations were conducted. A panel of 15 residents was identified, including: two tour operators, two real estate agents, one constructor, one designer, one police officer, one nurse, three people involved in higher education, one cleaner, one driver, one warehouse supervisor and one communications operation officer. The panel provided illustrative information about public opinion. In addition, 13 key stakeholders were interviewed, including officials in Ministry of Land Management, Urban Planning and Construction, (MLMUPC), Ministry of Public Works and Transport (MPWT), Ministry of Water Resources and Meteorology (MOWRAM), the Phnom Penh Municipality Hall; Ministry of Environment, GGGI, UNDP, Cambodian Institute of Urban Studies, Cambodian Green Building Council and four private sector developers and architects.

3.1 Level of awareness of green infrastructure

Public panel. The range of awareness in the public panel of what is defined as GI is illustrated in Figure 6. Trees and gardens are widely known and understood as GI assets. Rain gardens, private gardens, tree pits and green walls are also recognised by about half the panel. Other GI assets (e.g., green roofs, ponds, verges and swales) are less widely recognised.

Figure 6 Public perception of what is defined as GI assets



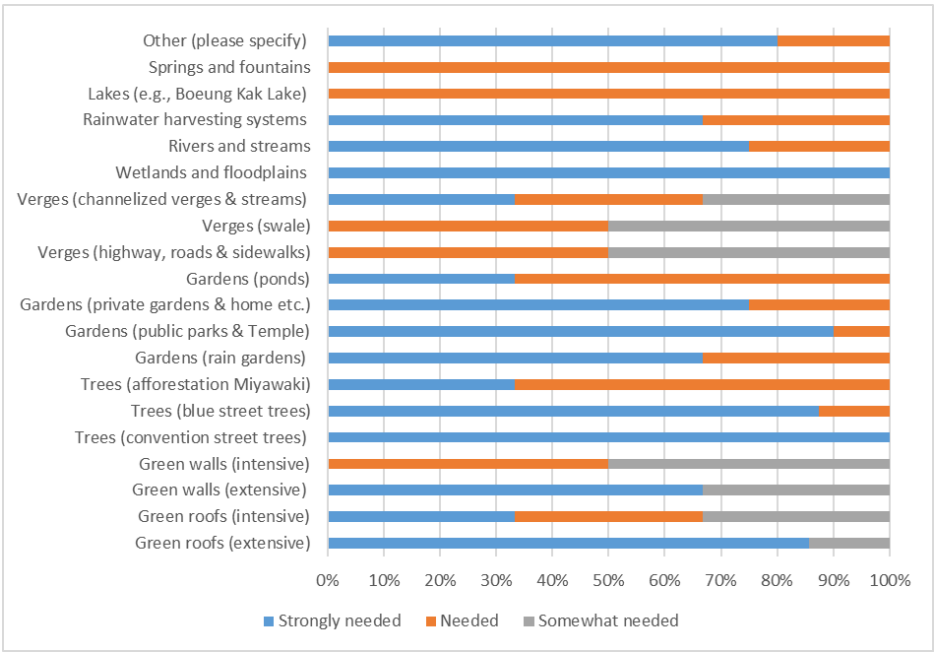
Key informants. Most of the key informants were aware of the general design features of GI assets. However, as with the public panel, the key informants were aware mainly of trees, parks and gardens and few key informants referred to rain gardens, permeable pavement, park, bioretention areas, riparian buffers and rain harvesting as examples of GI.

3.2 Demand for GI

The public panel and key informants were asked about their views on the demand for urban GI to provide evidence about the level and breadth of interest in GI.

Public panel. The opinions of the public panel are presented in Figure 7, which suggests that the most strongly needed GI assets were wetlands and floodplains and street trees, closely followed by public parks and temples, street trees with pits and extensive green roofs. Rivers, streams, private gardens, rainwater harvesting, rain gardens and extensive green walls were also considered important. There was less need for intensive green walls, verges and intensive green roofs.

Figure 7 Level of perceived need for GI assets



Key informants. The key informants expressed the following views on demand for GI.

- Private companies suggested that the following GI assets were most needed: trees along the roads, open spaces, gardens, grass and ponds. Private developers already include these GI into the design and construction of their developments. Their source of evidence on demand for GI comes from: customer research; ideas from architects and designers from other countries; and ideas from Cambodian developers who make visits to other countries.
- It is difficult to estimate average or standard values for the additional costs of including GI in development as it depends on the projects. Some key informants said 10-20% additional costs and some cited 30-40% additional costs. Some key informants said that the GI investment costs may be lower than conventional infrastructure, but the operation and maintenance costs are higher.
- Participants believe that public demand for GI over next 10 years is likely to be much higher than over the past 10 years for the following reasons: increased incomes in the city; improved knowledge and awareness on the importance of GI; and an increasing demand from citizen who choose to live and work in environments that are better for health and help relieve stress.
- There are some existing initiatives to encourage GI such as: some existing regulations and guidelines on building standards; promoting a clean city and waste management; encouraging plant trees; and world environment days. The Cambodia Green Building Council supports a Cambodia Energy and Environmental Leadership (CAMEEL) initiative, with four levels of certification based on a points system. CAMEEL also operates a system of professional credentials, allowing property professionals to describe themselves as either a CAMEEL Associate or a CAMEEL expert[3].

3.3 Risks addressed by GI

The consultation asked the public panel and key informants about their views relating to the risks addressed by GI. The responses were used as part of the assessment of the extent of awareness about the potential benefits of GI and provided the basis for the assessment of perceived benefits presented in section 3.5.

Public panel. The public panel were asked about their views on climatic and non-climatic risks over the last 10 years. This provides an indication of the extent to which the risks addressed by GI feature strongly in residents' concerns. The following risks are reduced using GI: flooding (87%), lighting (53%), drought (40%), heat stress, water pollution and drainage (33% each.), storm surges, sewage overflows, epidemic and traffic congestion (27% each), typhoons, irregular rainfalls and dry spells, fire, riverbank collapse, pest outbreaks and unregulated parking (20% each) and unregulated construction (20%).

Key informants. The risks addressed by GI that were most cited by key informants were: flood (especially flash flood) and heat stress. The second most cited risks were: unregulated construction, traffic congestion and ground water recharge. Participants also cited risk of water pollution and issues related mental health. Floods cause damage to housings and roads, some disruption on education and some disruption of street and informal small business (especially flash floods).

Risk hotspots in Phnom Penh. The most vulnerable areas are in central, crowded areas in the city (along the river, south and west of the city), low lying areas where there the drainage system becomes blocked with heavy rainfall and infrastructure is not developments causing flooding, other areas where there are epidemics and natural disasters and areas with a lot of squatter structures. Heat risks are highest in the centre with a lot of buildings and little space and trees. New developments and outskirts of the city are also exposed. Those include areas in Dangkor, Prek Thnot stream, along

[3] https://camgbc.org/photo-gallery.html

national road 4, Boeung Cheung Ek and Prek Phnov. Other frequently sited areas considered the riskiest are: Chomchao market, Klang Romsev market, Boeung Kak, Kour Srov, Street 2004, Khan Meanchey, Steung Meanchey, Depo market, Boeung Tumpun, Kobsrov, Dongkor, Teuk Laak, Tep Phorn, Sen Sok, Phnom Penh Thmei Kombol and Mondial.

3.4 Challenges in implementing GI and responses to the challenges

The survey asked the panel and key informants for their views on the seriousness of the challenges in implementing GI. The results of this consultation were used to inform the suggestions relating to the financing and policy framework, including the supporting policies, and the overall recommendations in the final chapter.

Public panel survey. The challenges and barriers for GI implementation cited by the public survey include:

- growth in hard infrastructure development, including road infrastructure or other structures (both public and private)
- growth in water pollution
- the amount of solid waste increased significantly
- increased traffic
- growing land demand for economy growth
- population growth
- a lack of public awareness of the benefits of GI
- a decline in farming because but some Borey/flat owners leave too little space to plant home gardens or allotments

The responses to these challenges include:

- promote vegetable farming in front of homes
- planning, development and maintenance of towns and transport infrastructure for local landscaping, enhancing habitats and biodiversity, including installing streetlights, wide and clean roads, wildflowers and open fields
- community greening campaigns including planting, maintaining and regularly improving GI such as trees, gardens, ponds, or green areas and encouraging participation in responding to climate change more widely
- the education sector should integrate knowledge awareness, accompanied by public education campaigns for GI through primary, secondary and tertiary education institutions and raise awareness through television and media broadcasts
- the government should improve the solid waste management system
- the government should upgrade the sewer drainage and storm water system to improve water flow and prevent flooding
- the government should provide land for people to plant more trees, as well as protect existing forests and stop deforestation
- attract tourist to the city through “one person, one tree”
- the government should be prepared to act pre-emptively to prevent risks and adapt to climate change and not only provide emergency response. This includes reducing sedimentation of ponds and rivers, helping high risk flood victims find safe shelter, first aid and protection against diseases, avoiding damage of and rebuilding infrastructure and offering food aid using private funds, or in the form of daily food allowances
- the Ministry of Land Management should have strict policy for investment in GI projects when considering whether construction permits are granted

- state institutions need to continue to enact laws and response measures and incorporate climate change issues into national and sub-national and socio-economic development policies and plans
- private companies and the public should give donations for street trees in the city

Key informants. The challenges and barriers for GI implementation included the following:

- lack of public infrastructure to compliment/support private GI initiatives (e.g., bioretention areas and bioswales need to connect with public drainage)
- lack of interest and investment from some private project owners
- lack of regulations and guidelines for GI
- limited understanding of the concept of GI
- limited spaces for GI in the city centre
- pressures on private developers for rapid development
- lack of incentives for GI development
- lack of financial resources to implement public GI
- lack of access to quality trees and seedlings for planting

The key informants suggested that responses to these challenges include:

- development and enforcement of guidelines and regulation on GI, including green building codes, standards and certification
- tax incentives for GI materials, both imported and domestically produced
- green finance including green bonds, preferred interest rates for green loans along with supporting
- guidelines to improve access to green incentives and finance
- encouragement of renewable energy, including through regulations about minimum standards
- financial resources for public GI to support the growing population and housing demands in Phnom Penh
- increased awareness and experience amongst private developers in the design of housing development to include GI in projects
- improvement of urban planning and architecture including reserving green spaces in land and housing developments; zoning for green spaces; encouraging people to plant more trees, create more sidewalks and greener malls and cafeterias in Phnom Penh; promoting more knowledge and interest in green concepts amongst architects and designers
- changing public behaviour towards GI, including participation in maintaining green spaces (e.g., proper waste management) and developing small gardens and green roofs/walls at home,
- public green procurement, green labelling and energy audit certification
- education on green policies and curriculum on green issues in education institutions

3.5 Perceived benefits from GI

The consultation asked the public panel and key informants for their views about the relative importance of the various benefits provided by GI. This evidence was compared with the evidence on the value of benefits from the literature review in the next chapter. There was broad agreement on the importance of benefits, although the consultation suggested that reduced air pollution and carbon sequestration was valued more highly in Cambodia than in the studies reviewed in the next chapter. There appear to be good reasons why both of these benefits could be more important in current day Phnom Penh, but the brief nature of the survey did not provide evidence in a format that was considered sufficiently quantitative to make changes to the unit benefits suggested in the literature.

A much larger survey, with an explicit approach to valuation of benefits, would be needed to provide values specifically for Cambodia.

Public panel. Table 3 summarises the responses from the panel consultation on the perceived importance of the range of benefits from GI assets. Reducing pollution and the urban heat island effect and improving the environment (both indoor and outdoor) and mental health received the highest average scores. The least important benefits were those related to water quality, carbon, energy efficiency, physical activity and noise.

Table 3 Level of importance of GI benefits

Level of important of GI benefits	Average level
Water quality benefits	
Water infiltration	3
Reduce pathogens, nutrients, sediment and heavy metals in water	3
Replenish groundwater reserves	4
Slowing and reducing storm water discharges	4
Reduce pumping and treatment demands for municipalities	4
Reduced combined sewer overflows	3
Air quality benefits	
Filtering dust, chemicals and metals suspended particulate matter	4
Reducing power plant emissions associated with air conditioning	4
Carbon sequestration	4
Reduce smog causing respiratory problems	5
Climate-related benefits	
Reduce urban heat island effect	5
Low carbon development (embedded carbon in materials for buildings)	3
Energy efficiency	3
Flood mitigation	4
Relieving stress on local water supplies, improving the quality of potable water	4
Other (please specify)	4
Health benefits	
Improve mental health	5
Improve satisfaction of living in the city	4
Encourage outdoor physical activity, reducing obesity and chronic diseases	3
Reduce noise pollution by damping traffic, train and plane noise	3
Improve a healthy indoor environment	5
Improve the walkability and “bike ability” of the city	4
Promote urban livability and urban comfort	4
Create more social inclusion, sense of community by having places to socialize	4
Make the city more pleasant scenery and beautify the city	5

The perceived benefits presented in Table 3 can be compared with the evidence from the literature on the relative value of different types of benefits, presented in Figure 8 and Table 9. The literature suggests that the most important benefits are those related to cooling and quality of life. This is consistent with the perceptions of the public panel which gave a top score of 5 to reducing the heat island effect and to various aspects of quality of life, including mental health, a more pleasant city and healthy indoor environment. Flood protection was slightly less important in the literature on valuation, but still had high values, which is consistent with the scores of 4 assigned by the public panel. Reduced air pollution was less highly valued in the literature on valuation but received high

scores from the public panel. The benefits related to biodiversity and inward investment were not considered in the survey.

The lower values associated with carbon sequestration in the literature were consistent with scores given by the public panel for low carbon development (3) and energy efficiency (3). The higher score of 4 given to carbon sequestration by the panel may reflect the higher profile of climate change in current public awareness, which will also be reflected in higher values in valuation studies, as the prices used for carbon increase with the more ambitious plans for carbon neutrality.

Key informants. The key informants recognized a wide range of benefits from GI initiatives, including reduced air and noise pollution; increased biodiversity; cooling and shade; carbon sequestration; a potential increase of local and international tourism; and landscape aesthetics. The most cited strengths and opportunities were attractive places for medium and high-income residents who are willing to pay premium prices; attracting investment by entrepreneurs; new experiences of green scenery for customers who visit parks; attracting more visitors (both tourists and Cambodians); and popular community malls and parks including organic and healthy products.

On water quality, key informants mostly cited the benefits of replenishing groundwater reserves, reducing sewer flows and slowing and reducing the storm water discharges.

- On air quality, key informants often cited the benefits for respiratory problems of reducing air pollution and filtering dust and chemicals.
- On climate change adaptation, key informants recognised the benefits of energy efficiency, flood mitigation, relieving stress on local water supplies and improving quality of portable water, carbon sequestration and low carbon development.
- On health and wellbeing, key informants cited the benefits of: improved mental health; improved satisfaction of living standards in the city; greater outdoor physical activity, reducing obesity and preventing associated chronic diseases; improved and healthy indoor environment; improved walkability and “bike ability” of the city; improved urban ‘liveability’ and comfort; and more pleasant scenery and beautification of the city.

The consultation did not explicitly ask interviewees to associate benefits with different GI assets. However, an assessment is possible, based on responses across each interview and this is presented in Table 4.

Table 4 Perception of benefits associated with GI assets

Benefits	Trees (conventional street trees)	Gardens (public parks, sports facilities)	Trees (blue street trees)	Gardens (private home gardens)	Gardens (rain gardens)	Green roofs (extensive)	Gardens (ponds)	Green walls (extensive)	Green walls (intensive)	Verges (highways, roads, and sidewalks)	Lakes	Green roofs (intensive)	Verges (channelized verges and streams)	Springs and fountains	Trees (afforestation Miyawaki)	Wetlands and floodplains	Rivers and streams	Verges (swale)	Importance
Reduce noise pollution by damping traffic, train, and plane noise	●●●	●●●	●●●	●	●	●	●	●●	●●	●●●	●	●	●	●	●●	●	●	●	100.00
Improve the walkability and "bike ability" of the city	●●●	●●●	●●●	●	●	●	●	●●	●●	●●●	●	●	●●●	●	●●●	●	●●	●●●	100.00
Reduced combined sewer overflows	●●	●●	●●	●	●●●	●●●	●●●	●●	●●	●●●	●●●	●●●	●●●	●●	●●●	●●●	●●●	●●●	93.33
Reduce smog (nitrogen oxides, volatile organic compounds, heat, sunlight) causing respiratory problems	●●●	●●●	●●●	●●	●●	●●	●●	●●●	●●●	●●●	●●	●●	●●	●	●●●	●●	●●	●●	93.33
Make the city more pleasant scenery and beautify the city	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	93.33
Water infiltration and replenish grounwater reserves	●●●	●●●	●●●	●●	●●●	●●	●●	●	●	●●●	●●●	●●	●●●	●●●	●●●	●●●	●●●	●●●	86.67
Reduce pathogens, nutrients, sediment, and heavy metals in water	●●●	●	●●●	●●	●●	●	●	●●	●●	●●●	●●●	●●	●●●	●●●	●●●	●●●	●●●	●●●	86.67
Slowing and reducing storm water discharge	●●	●●●	●●	●●	●●●	●●	●●	●●	●●	●●●	●●●	●●	●●●	●●●	●●●	●●●	●●●	●●●	86.67
Reduce pumping and treatment demands for municipalities	●	●	●	●	●●	●●	●●	●●	●●	●●●	●●●	●●	●●●	●●●	●●●	●●●	●●●	●●●	86.67
Carbon sequestration	●●●	●●●	●●●	●●	●●	●●	●	●●	●●	●	●	●●	●●	●●	●●●	●●●	●●	●●	86.67
Filtering dust, chemicals, and metals suspended particulate matter	●●●	●●●	●●●	●●	●●	●●●	●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●	86.67
Reduce urban heat island effect	●●●	●●●	●●●	●●●	●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●	●●●	●●●	●●●	●●	86.67
Create more social inclusion and sense of community by having places to socialize	●	●●●	●●●	●●	●	●●	●●●	●	●	●●	●●●	●●	●●●	●●●	●●●	●●●	●●●	●	86.67
Improve mental health	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	86.67
Encourage outdoor physical activity, reducing obesity and preventing associated chronic diseases	●●	●●●	●●●	●●	●	x	●●●	x	x	●●●	●●●	x	●●●	●●●	●●●	●●●	●●●	x	80.00
Promote urban liveability, urban comfort and satisfaction of living in the city	●●●	●●●	●●●	●●●	●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	80.00
Reducing emissions associated with air conditioning	●●	●●	●●	●●●	●●	●●●	●	●●●	●●●	●	●	●●●	●	●	●	●	●	●	73.33
Reducing dependence on embedded carbon in materials for construction of the built environment	●●	●●	●●	●●	●●	●●●	●	●●	●●●	●●●	●	●●●	●●●	●	●●	●●	●	●●	73.33
Flood mitigation	●	●●●	●●●	●●	●●	●	●	●	●	●●●	●●●	●	●●●	●●●	●●●	●●●	●●●	●●●	73.33
Relieving stress on local water supplies and improving the quality of potable water	●●	●●	●●	●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●	●●●	●●●	●●●	66.67
Improve a healthy indoor environment	●	●	●	●●●	●	●●●	●	●●●	●●●	●	●	●●●	●	●	●●	●	●	●	66.67
Energy efficiency	●	●	●	●	●	●●●	●	●●●	●●●	x	x	●●●	x	x	x	x	x	x	60.00
Importance	100.00	100.00	85.71	85.71	57.14	42.86	35.71	28.57	28.57	28.57	28.57	21.43	21.43	21.43	14.29	14.29	14.29	7.14	

Note: Benefits are non-exclusive. Percentages of importance are elicited from respondents' perceptions of the public survey while dots represent the level of importance of the benefit derived from the GI type, based on expert opinion of report authors. X = not applicable.

4 Cost and benefits of green infrastructure assets

This chapter describes the results of a literature review to obtain evidence on the costs and benefits of investing in and maintaining GI. The chapter first aims to convert the evidence into standard units of USD/m^2 or USD/tree. It then proposes typical values that can be used as yardsticks and estimate the benefit cost ratio (BCR) of 14 types of GI asset. Finally, the chapter suggests a scenario of investment in the expansion of GI which will bring Phnom into line with the levels of GI that are common in other Southeast Asian countries.

4.1 Unit costs of GI

Based on a review of 40 studies, Table 5 summarises the evidence found on the unit costs of GI. Much of the evidence comes from developed countries and the analysis assumes that costs in Cambodia will be roughly a third of the costs in developed countries, although the cost of trees are known to be expensive in Cambodia and these are not reduced. Operation and maintenance costs (OPEX) are assumed to be 5% for most GI assets, but higher for a few assets that require more work (e.g., ponds, miyawaki forests). Extensive green roofs and green walls are assumed to require no maintenance because this approach is favoured in some countries.

Table 5 Evidence on unit costs of GI (USD/m^2 or USD/tree)

Type	Unit cost		Evidence on unit cost
	CAPEX	OPEX	
Green Roof			
Green roof (intensive)	100	2	• Retrofit costs of 100 USD/ m^2 (City flood map, 2020) • UK costs 80-90 £/m^2 (Defra et al., 2013) - assume 2% OPEX costs per year
Green roof (extensive) = roof garden	75	0	• 75% of CAPEX of intensive and no maintenance
Green Wall			
Green wall (intensive)	100	2	• No direct evidence – assumed to be the same as green roofs
Green wall (extensive) = climbing plants	50	0	
Trees			
Street trees	20	1	• California maintenance costs 19 USD/tree (McPherson et al, 2015) • Maintenance costs of 6 USD/tree/year (Vogt et al., 2015)
Street trees (blue)	25	1.25	• Based on other trees + 5 USD/tree for the pit
Miyawaki forest	30	5	• 300-350 Rs/ft^2 establishment (crowdforesting.org)
Park and Garden			
Rain garden	30	1.5	• 10-12 USD/ft^2 in US in 2003 (Bannerman and Considine, 2003)
Public park or garden	15	2.5	• Park establishment costs of 50 to 200 £/ m^2 in UK (Holden, 2007) Glasgow Park restoration 40 USD/ha, Liverpool community woodland 1200 USD/ha (Naumann and Rayment, 2011)
Private garden	50	2.5	• Highly varied costs
Ponds/wetlands	20	2	• 15-30 £/ m^3 in UK assume 1m depth (DEFRA et al, 2015)
Verge			
Highway verge	7	0.4	• Assumed to be the same as swales
Swale	7	0.4	• 10-15 £/ m^2 establish 0.1 £/m^2 maintenance In UK (DEFRA et al, 2015)
Canalised rivers/streams			• No evidence found

[1] all values are USD/ m^2 or USD/tree, unless stated

4.2 Unit benefits of GI

The main types of benefits from GI are listed in the typology presented in Table 1.

Approaches to valuing GI benefits. The approaches to valuing GI benefits are as follows.

- *Health.* Benefits relate to reduced mortality and morbidity can be valued by estimating the lost economic activity using measures like Disability Adjusted Life Years (DALYs). This is a direct estimate of impact on GDP.
- *Productivity.* Reduced labour productivity from heat stress can also provide an estimate with a direct impact on GDP.
- *Reduced energy costs.* Reduced energy costs also have a direct impact on GDP, generating income that can be used to give higher returns on capital and/or labour.
- *Flood protection.* The benefits of flood protection can be measured in terms of reduce loss and damage. In theory, losses are direct reductions in GDP and damage does not directly reduce GDP but rather diverts investment from growth to reconstruction. If the investment diverted yields substantially positive Benefit Cost Ratios (BCRs) then the net impact on GDP of flood damage avoided should be substantially higher than the cost of repairing the damage. However, in practice, avoided loss and damage are usually treated as a simple reduction in GDP.
- *Quality of life – health benefits.* There may be some physical and mental health benefits for which direct estimates of changes in loss of GDP can be made.
- *Quality of life – property value.* Some quality-of-life evidence is derived from figures about higher property values and rents near GI. This has a direct impact on GDP because actual rents (for tenants) and imputed rents (for owner-occupiers) are an important component of GDP, typically contributing as much as 10% of GDP.
- *Quality of Life – willingness-to-pay.* Another source of evidence on the value of GI assets comes from asking people about their willingness-to-pay for GI. This is not currently captured by GDP, although there has been some work on the possibility that unpaid activities could be included (Ven et al, 2018). Evidence from willingness-to-pay is useful as a source of validation for other evidence, but it is difficult to collect and there are risks that it could duplicate evidence from property values.
- *Carbon.* In theory, the valuation of reduced GHG emissions should use the social cost of carbon (SCC) which should reflect the reduced impact of climate change on GDP. In the past, this has sometimes been treated as a theoretical exercise, but the rapidly growing priority given to climate change mitigation suggests that it is now accepted that the valuation of GHG emission reductions should be treated as a direct impact on GDP.
- *Inward investment.* Inward investment attracted by improved conditions and productivity near GI assets generates growth in value added, including increased returns on capital (e.g., profits) and labour (e.g., salaries). From the perspective of Cambodia as a whole, inward investment in the locality of GI assets that comes from Foreign Direct Investment (FDI) is more likely to be genuinely incremental that domestic investment[4].

Case study evidence. Table 6 summarises the evidence from case studies on the benefits from GI, with a particular focus on experience in Southeast Asia.

[4] In practice, the distinction between FDI and domestic investment is not clearcut: FDI near GI assets might have been made in other locations; and domestic investment near GI assets might be incremental, if investors are convinced that returns will be higher as a result of the benefits of operating near GI assets.

Table 6 Key quantitative evidence on GI benefits

Group	Benefit	Evidence of Benefits
Cooling	Health and productivity	• Productivity benefits in nine places (China, Japan, London) worth average 1.07 USD/m^2 (Gunawardena et al., 2017) • 7.4 deaths saved for every km^2 per 1000 people (Dang, et al., 2018) • Net Present Value (NPV) of mortality/morbidity benefits of about 750 USD/households in Melbourne (Whiteoak and Saigar, 2019) • Labour productivity in Cambodia falls by 1.8% per 1℃ rise, across all sectors (Ministry of Economy and Finance, 2018) • Labour productivity falls by 7% for everyone 1℃ increase in temperature (UNDP, 2016) NPV of labour productivity of 179 USD/household in Melbourne (Whiteoak and Saigar, 2019) • 2.7% of GDP lost for 0. 1℃ rise in temperature (Kjellstrom and Meng, 2015) • 2.3ha park reduced temperature by 0.931℃ for distance of 60m (Aram et al., 2019) • Green roofs/walls cool by 3℃ (Zupancic et al., 2015)
	Reduced energy costs	• NPV of energy benefits of 680 USD/household in Melbourne (Whiteoak and Saigar, 2019) • 3-9% reduction in heating bills near stream (Gore et al., 2013) • Lower costs of operating equipment in Phoenix worth 0.3% of GDP if UHI avoided (Miner et al., 2016) • Tree shade can reduce cooling costs by 20-50% (Rahman and Ennos, undated)
	Workplace breaks	• No evidence was found on this
	Mental well-being	• No evidence was found on this
Lower pollution	Health and productivity	• Pollutant removal worth 58m £/year in Inner London with tree cover of 4,000ha (13% of total) (Treeconomics, 2015) • 35% reduction of particulates near GI in Seoul (Gore et al., 2013) • Value of air cleaning of 50USD/tree (Treeconomics, 2015) • 50ha green roofs remove 0.21t of PM10 particulates (Zupancic et al., 2015)
Quality of life	Civic pride/identity	• Review of 15 willingness to pay studies for nearby GI with average 31 USD/year and 10 studies 10 to 35 USD/year (Gunawardena et al., 2017)
	Social meeting place	
	Views	
	Beautification/inspiration	
	Space for sports/leisure	• Health benefits from regular exercise in UK worth 300 £/person /year (Gore et al., 2013)
	Reduced crime	• No evidence was found on this
Biodiversity hotspots and corridors	Species diversity and habitat extent/quality	• No evidence found on this
	Public engagement	
Flood reduction	Retention, detention, infiltration, evaporation	• USD10.3m mixed GI scheme in Bangkok reduced flood clear-up costs by USD28.9m (CRCSC and ICEM, 2021b) • runoff reduced by 35% for 10% increase in tree cover in Seoul (Gore et al., 2013) • flood model for GI interventions reduced flood depth from 0.38-0.2m in Melbourne (Webber et al., 2020) • Flood risk reduced by 15% to 38% for different GI scenarios in Istanbul (Gunawardena et al., 2017)
	Drainage	
Public attitudes	Reduced solid waste	• No evidence found on this
	Neighbourliness	

	Increased volunteering	
Food	Quality of local food	• No evidence found on this
	Food choices	
	Rainwater harvesting	
Carbon	Carbon saved is cooling energy efficiency	• Energy savings from urban forest shade and climate regulation in US of 0.34 to 1.35 tC/ha/year (Gunawardena et al., 2017)
	Sequestration from plants, soil and wetland ecosystems	• Review of 21 studies of urban trees gave total value for city and 0.75 to 10 USD/tree, 18 kgC/tree/year and 3.6 to 11 tC/ha (Gunawardena et al., 2017)
	Reduced cement use	• No evidence found on this
	Reduced food miles	
Housing	Increased property values	• 20 studies reviewed with average price benefits of 164 USD/m2 near park/forest (Gunawardena et al., 2017) • USD10.3m mixed GI scheme in Bangkok increased property values by USD88.3m (CRCWSC and ICEM, 2021b) • Property values mostly 7% to 25% higher near GI (Forest Research, 2010) • Property values up USD16,000 (8%) near GI, based on 15 case studies, assuming USD200K house (Gunawardena et al., 2017) • Municipal taxes up 47% (Gore et al., 2013)
	Building new homes	
New business	Tourism, leisure, GI design and maintenance	• Visitors in Glasgow spent £2 for every £1 invested in GI (Gore et al., 2013)
Inward investment	Growth in jobs	• Ratio of new value added to GI cost was 2.3 in Mersey Forest and 4.2 in Portland Green Business Park (Forest Research, 2010) • Glasgow green jobs up 28% compared to city average of 13% (Gore et al., 2013)

Note: Figures are presented in the currency reported in studies

Box 1 Summary of Nou Thesis on potential of GI to reduce urban run-off in Phnom Penh

Chanrachna Nou undertook a Master's thesis on *The Potential of Green Infrastructure to Reduce Urban Run-off in Phnom Penh City* (Nou, 2019). The thesis reviews the nature of localised flooding in Phnom Penh, drawing on 5 studies conducted between 2012 and 2017. This review shows that 26 communes experienced flooding during this period. Rainfall events varied from 27 to 392 mm in total and run-off varied from 1.8 to 183 m^3/s, with most events in the lower end of these ranges.

In 2017 in Phnom Penh, 21.4% of the area was classified as residential urban fabric, 11.5% as industrial and commercial, 24.6% as agriculture, 14% as water; 13.3% as unused, 7.1% as natural and semi-natural and only 1.3% as urban greenery and recreation.

The study then reviews the following types of GI and international evidence on their potential for reducing run-off. Key finding found:

- Trees intercept between 7 and 27% of rainfall, equivalent to 3 to 8 m^3/tree, depending on the species (Elliott et al., 2018).
- Swales are reported by three studies to reduce runoff by between 85-99%, with rainfall events of between 83 and 446mm.
- Permeable pavements can take various forms. Evidence from three studies suggest reductions in runoff of 44% to 100%, with rainfall events of 81 to 135mm.
- Green roofs are assessed with reference to six studies with runoff reductions of 18 to 68%. Most relate to annual rainfall, but one refers to two rainfall events of 43mm (with 42.8% reduction in runoff) and 16mm (60.8% reduction).

The study modelled rainfall events and runoff in three areas, with GI options including trees (14-22% of GI, depending on the area), green roofs (12-25%), swales (1-2%) and permeable pavements (61-65%). The reduction in peak runoff rate was closely related to the area covered by the GI although there were variations in the runoff reduction per m^2 in the different areas. The total area covered by all GI elements in the three areas was 47%, 57% and 43% and the runoff reduction was 31%, 49% and 39% respectively, suggesting that larger area coverage was effective in terms of reducing runoff. This appears to be largely because of some particularly effective permeable pavements, especially on streets.

There has been no comprehensive assessment of the average annual impact of floods in Phnom Penh. Box 2 presents some of the evidence, which suggest that average losses in Phnom Penh are between 3-10m USD/year. These losses related largely to localised flooding after periods of intense rainfall that affects localities. Most studies report flood volumes in terms of runoff values. For example, 4-10 m^3/second are typical (Yim et al., 2015) and another study suggested typical flood volumes are over 1 million m^3 (Irvine, et al., 2015). Although the benefits from storing flood water are not linear, as a first approximation, this would suggest a value of between 3-10 USD/m^3 of water storage capacity. The final column of Table 7 assumes a value of 10 USD/m^3.

Table 7 Water storage potential of GI assets

GI asset	Unit	Water storage potential[1] (m3/unit)	Storage benefit[2] (USD/unit)
Green roof	m^2	0.2	2.0
Green wall	m^2	0.1	1.0
Trees	Tree	1.0	10.0[3]
Garden/park	m^2	0.2	2.0
Ponds	m^2	0.2	2.0
Verge/swale	m^2	0.2	2.0

[1] water stored over a typical storm event of 200mm, based on Box 1

[2] assuming 10 USD/m3 value, based on the paragraph above the table

[3] the benefits for trees are per tree, not per m^2 (average canopy is about 8m^2)

It is not certain that widespread use of GI would prevent all these losses, but they are the sort of flood that GI can reduce significantly. A recent study of the significance of GI in reducing stormwater runoff in Phnom Penh suggested that using GI to increase pervious surfaces from 4% to 48% of the total area would reduce stormwater runoff by 38%, equivalent to a reduction in 1.55 m^3/second (Nou and Charoenkit, 2020). This affect was achieved through about: 20,000 m^2 of green roofs (or about 10% of total roof area); 114,000 m^2 of permeable block paving, asphalt and concrete (or 87% of this area); 1,800 m^2 of bioswales; 16,000 m^2 of additional tree cover; and 2,200 m^2 of tree pits.

Box 2 Flood damage in Phnom Penh

A review of flood damage in Phnom Penh suggested that a typical low-level flood lasting a few hours cost each person affected about USD37 (Khan, 2019). The frequency and severity of local floods was not described, which makes it difficult to assess the benefits of reducing the floods, but one scenario is that 10 such events happen across Phnom Penh during the rainy system each one affecting 10,000 people. Under this scenario, total economic costs would be 3.7m USD/year.

A review of flood damage between 1996 and 2013 suggested that 579 houses were destroyed and 883 were damaged in Phnom Penh over the period (NCDM and UNDP, 2016). There is no data on the size, location and value of houses but, if the average damage was 100,000 USD/house, this would suggest total damage of USD 146m over 18 years, or 8.1m USD/year. The report also

recorded 20 deaths and, although floods were the accounted for most deaths nationwide, it is not stated explicitly whether this was also the case in Phnom Penh. The valuation of human life is a complex and sensitive topic but one suggestion is that USD 400,000 is the correct figure for Cambodia (Cameron et al., 2008). This would suggest that avoiding loss of life from flooding in Phnom Penh is worth about 1m USD/year.

In October 2020, floods affected the whole country. In Phnom Penh, the floods affected: 5,587 households, of which 1,593 were displaced; 10 km of roads; and 1,350 ha of agricultural land. All households affected received emergency help (HRF, 2020).

In October 2021, the ASEAN Disaster Information Network reported that floods in Phnom Penh had affected 12,500 people and about 3,000 houses in Phnom Penh.

Cooling and the urban heat island effect. The relationship between temperature and labour productivity has received increased attention in recent years, both internationally (UNDP, 2016) and in Cambodia (Kjellstrom, et al., 2016; Ministry of Economy and Finance, 2018). The Cambodia CEGIM analysis suggests that labour productivity across all sectors will decline by 1.8% for every degree of increased temperature.

When GI assets cool the atmosphere, this also results in reduced energy bills in surrounding properties. In one study, energy bills were reduced by between 3 and 9% (Gore et al., 2013) and the analysis assumes that half the average utility bill in Phnom Penh is devoted to cooling and that the costs of cooling are reduced by 5% for every 1°C reductions in temperature caused by GI[5].

A recent study of the cooling effect of parks reviewed 15 empirical studies the majority of which were in China (Aram et al., 2019). The review considered the area of the parks, the temperature reduction and the distance over which that reduction was felt. The results of the review are presented in Table 8, which assumes that the area affected around the park is populated at the average population density for Phnom Penh of 33.61 people/ha. The table calculates both the value of protecting labour productivity and reduced energy cooling costs and suggests that the average benefits are 1.07 USD/ m^2. The analysis assumes that the same cooling benefits apply to green roofs, green walls, parks, gardens, ponds and verges.

Table 8 Cooling benefits of park areas

Location	Authors	Park area (ha)	Cooling effect (C)	Distance (m)	People	Productivity Value (USD/yr)	Energy Savings (USD/yr)	Value (USD /m2)
China	Lin et al 2015	2.3	0.93	60	79	5,851	2,204	0.35
China	Lin et al 2015	35.8	4.43	279.19	1609	567,810	213,864	2.18
Nagoya	Cao et al 2010	41.9	6.82	200	973	528,479	199,051	1.74
China	Du et al 2017	1.1	0.78	90	141	8,754	3,297	1.08
Nagoya	Hamada/ Ohta 2010	147.0	1.90	400	3781	572,203	215,519	0.54
London	Doick et al 2014	111.0	4.00	440	4161	1,325,635	499,298	1.64
London	Vaz et al 2016	1.0	0.30	40	35	835	315	0.11
London	Vaz et al 2016	4.0	0.70	95	185	10,325	3,889	0.36
London	Vaz et al 2016	12.1	1.00	330	1850	147,342	55,496	1.68
Average								1.07

Source: Aram et al., (2019) for park area and cooling effect, authors' calculations for value of benefits
Note: the Cao et al study did not specify the distance and 200m has been assumed

For trees, a review in found that the temperature under trees is often 10°C cooler than in open sunshine (Pace et al., 2021). The wider cooling effect is more complex and occurs because of the

[5] https://www.numbeo.com/cost-of-living/country_result.jsp?country=Cambodia

cooling effect of evaporation, not shade. The study suggested that this was about 2.5°C, although the distance over which this affect is felt was not specified. If a single tree reduced the temperature around one household by 2.5°C, the benefit would be 7.5 USD/tree (e.g., USD 500 x 5% x 2.5°C).

For green roofs and green walls, cooling effects of 3°C are common (Zupancic et al., 2015). If these effects can be achieved from 4 m^2 of roof or wall and benefits 4 residents, the benefits from health, productivity and energy savings are about 33 USD/ m^2.

Pollution filtering. There is strong evidence of the value of trees in reducing carbon monoxide, nitrogen dioxide, ozone, particulates and sulphur dioxide. A study in London valued these benefits at £14,500/ha of tree cover a year, equivalent to 2 USD/m^2/year. The same study suggested the average tree cover of 25 m^2/tree, suggesting a pollution filtering benefit of 50 USD/tree/year. Health benefits are typically estimated using metrics like Disability Adjusted Life Years (DALYs) that are linked to per capita incomes. Per capita GDP, calculated in terms of purchasing power parity, in Cambodia is roughly one tenth of the level in developed countries[6], suggesting that the pollution filtering benefits in Cambodia are about 5 USD/tree/year, for a fully grown mature tree with a substantial tree canopy.

For green roofs and green walls, a study in Manchester suggested that 500,000 m^2 of green roofs would reduce PM10 particulates by 0.21t/year (Zupancic et al., 2015). According to a study in London, the harm caused by PM10 particulates is valued at USD365,000 (Treeconomics, 2015) which suggests that the benefits from air pollution removal of green roofs is 0.15 USD/m^2. Adjusting this for the difference in per capita GDP between Cambodia and the UK suggests pollution cleaning value of 0.015 USD/m^2. No evidence has been found of the value of air pollution filtering of parks and gardens and verges and this study assumes that it is double the value for green roofs and green walls because the vegetation mass and height is greater than in green roofs and green walls, given the potential presence of bushes.

Health and well-being. There is great interest in the health and well-being benefits from having easy and regular access to GI. One study in the UK suggested that health benefits were worth about 400 USD/person/year (Gore et al., 2013). Assuming that the number of people affected by parc cooling, as presented in Table 8, is a reasonable proxy for the number of people using the park, the average use is 58 people/ha, which would suggest economic benefits related to use of the parc of exercise of 2.3 USD/m^2 of parkland. This needs to be reduced to reflect the different purchasing power of people in the US and Cambodia.

Well-being benefits are difficult to estimate and the most common method is to use property values as an indication of the value that residents place on the improvement in the quality of their life associated with living near GI. One study suggested that property prices are typically 7% to 25% higher near GI assets. The INFFEWS database suggested that the average increase in value for 20 studies was 16,428 USD/100 m^2 (Gunawardena et al., 2017). Phnom Penh houses have an average area of 72 m^2 and an average value of about USD100,000[7], which suggests an average increase of about USD10,000, or 10% in property value. This is a capital value and equates to an annual value of about 1,000 USD/household/year. The impact on house prices is typically measured for people within 100m of a GI asset, which would cover an area of about 8ha for a parc of 1ha. With an average population density of 34 people/ha in Phnom Penh, the 1ha parc would benefit 272 people, or about 50 households. Total benefits from the parc, as reflected in the additional rent that nearby households are prepared to pay, would therefore be USD50,000, or 5 USD/ m^2 of the parc. This is substantially higher than the results suggested by the 13 studies in the INFFEWS database that assessed willingness to pay for closeness to a park, which averaged 31 USD/person/year or 150 USD/household (Gunawardena et al., 2017).

[6] https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD
[7] https://www.realestate.com.kh/buy/phnom-penh/house/

No independent evidence was found of the effects of individual trees on well-being and property values. It is therefore assumed that the ratio of the benefits; tree and benefits/ m^2 of other GI is 7.5, which is the same as for the cooling effect.

Carbon sequestration. A typical mature tree in Phnom Penh has about 2 tons of dry matter which is about 60% carbon and sequesters about 4.4tCO2 over the lifetime of the tree. If the tree takes 20 years to mature, this is 0.22 tCO2e/year. The social cost of carbon (SCC) is a complex subject. In theory, it is a global price since the benefits from sequestration are shared globally. US administrations before Trump used a value of 50 to 60 USD/tCO2e. The Biden administration is undertaking a review of this and has been using an 'interim' value of 51 USD/tCO2e, pending the results of the review. This would suggest that the full value of carbon in urban trees is about 11 USD/tree/year. However, in September 2021, the British government published new guidance recommending using a dramatically higher carbon price of between 120 and 361 £/tCO2e, with a 'central series' figure of 241 £/tCO2e, equivalent to over 300 USD/tCO2e (BEIS 2021). This reflects the increased urgency of climate mitigation targets at the Glasgow COP and would have a major impact on global mitigation if similar values were used globally. One REDD+ carbon credit scheme in Oddar Meanchey used a price of 4 USD/tCO2e and this was widely recognised as far too low. Other REDD+ schemes globally have used a price of 10 USD/tCO2e but this price is likely to rise substantially as the full impact of the Glasgow agreement is felt. This GI study suggests using a figure of 20 USD/tCO2e as the price of carbon, giving carbon benefits of about 4.4 USD/tree/year. Miyaki forests sequester 1.8 kgCO2e/ m^2[8], which is worth 0.036 USD. There are no significant carbon benefits for other GI assets because most of the carbon sequestered by perennial plants decomposes each year.

Biodiversity. The valuation of biodiversity is a very difficult subject and studies report very different values. One study of the pharmaceutical and social value of genetic material for hotspot forests suggested biodiversity values of between 100 and 9,000 USD/ha, with a mid-range of between 200 and 500 (Pearce, 2001). These are relatively high value indigenous forests and there could be an argument that urban parks and trees will have much lower biodiversity value than natural indigenous forests. However, there is also an argument that urban green spaces and private gardens often act as a critical habitat for species that are at threat. Using a mid-range of 400 USD/ha gives a biodiversity value of 0.04 USD/ m^2, which makes biodiversity the least important of the main groups of GI benefits.

Inward investment. Assessing the value of inward investment is difficult because the first impact of GI is to encourage investors to relocate, not to invest more. However, Cambodia receives large volumes of international investment that would otherwise go to other countries and it seems likely that a significant proportion of the investment into locations close to GI will come from increased international investment, rather than relocation. There are several examples of significant impact on inward investment in localities that have invested in substantial GI assets. The Mersey Forest evaluation suggested that £2.3 of additional value added was generated for every £1 spent and the Portland Green Business Park evaluation found that USD4.2 of private investment was secured for every USD1 spent (Forest Research, 2010). But it is not clear whether this additional value added and investment simply relocated from other areas or was totally additional. The benefit cost ratios for each GI investment will depend on the specific nature of the investment but appear to extend beyond the immediately neighbouring locality. This study assumes that the economic benefits arising directly from additional investment will be twice the investment in GI, but that only half of this will be genuinely additional FDI that will flow into Cambodia and the other half will be investment that would otherwise have happened in other parts of the city or in other cities.

[8] http://urban-forests.com/impacts-2/co2/

Box 3 The Water Sensitive Cities Initiative and the INFFEWS Value Tool

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) was established in 2012 to improve understanding about the value of the contribution of water to the economy, quality of life and ecosystems in cities. The centre has undertaken over 40 case studies in Australia, 3 in China and has recently completed 4 case studies in the Greater Mekong Region (CRCWSC and ICEM, 2021e). The approach focuses on Nature-based Solutions (NbS), using an Integrated Urban Flood Management (IUFM) framework.

The CRC maintains the *Integrated Investment Framework for Economics of Water Sensitive Cities* (INFFWES) value tool, which is an extensive database evidence from case studies on the full range of market and non-market benefits associated with amenity, recreation, health, energy, water quality, biodiversity, aesthetics, cooling, carbon sequestration, pollution removal, flood control, groundwater, water supply and wastewater (Gunawardena et al., 2017). The scale and scope of the literature covering these issues is illustrated by the fact that, despite consulting 345 studies and finding relevant evidence in 194 of these, many of the case studies found independently in the research for this Cambodia review are not yet included in the INFFWES.

The four recent CRCWSC studies in the Greater Mekong Region adopted a consistent approach with five steps, including: i) defining the urban system context; ii) assessing flood risks; iii) identifying interventions using a standard retreat-adapt-defend approach; iv) assessing costs and benefits; and v) identifying financing mechanisms. The valuation of benefits included site-specific analysis of flood related benefits and use of the INFFWES database for comparative evidence on wider benefits. Key findings from each case study were as follows.

- In the Sukhumvit Green Triangle in Bangkok, total costs were USD11.1m about 60% of which was on green roofs, which USD1,4m on swales/tree-pits, USD1.4m on stormwater harvesting and smaller spending on planter boxes, wetlands and lake (CRCWSC and ICEM, 2021b). Thirteen benefits were valued, with over half from improved amenity along the canal, as reflected in housing prices, with significant additional benefits from reduced cleaning after floods and water quality. The overall Benefit Cost Ratio (BCR) was 14, driven by high benefits arising from the low-cost expenditure on improvements to the canal. Further work is required, especially on the costs and benefits of green roofs, given their importance in the actions proposed. The benefits are roughly evenly experienced by residents, enterprises, visitors and downstream communities protected from floods.
- The Rayong Central District Streetscape Greening proposal in Thailand involved USD3.6m investments, with 79% on primary roads, 20% on tree 'canyons' and smaller amounts on rainwater harvesting, infiltration greening and 'cool lines' for green routes(CRCWSC and ICEM, 2021a). About half the benefits came from the canyons, which deliver a very high BCR, with about 15% of benefits coming from primary roads, from reduced flood risks and from infiltration. The overall BCR was 9.7.
- Tam Phy Park in Ho Chi Minh City is a proposed urban wetland and social housing scheme and the case study involved altering an existing masterplan to be delivered with a hybrid design incorporating 20 elements of GI (CRCWSC and ICEM, 2021c). Total new costs were USD1.6m, with the largest elements being green space, water space, amusement area and drainage. Over half the benefits were associated with cost savings over the masterplan design and 30% of the benefits came from reduced flood risks. Smaller benefits from biodiversity and amenity value were assessed using the INFFWES value tool. The overall BCR was exceptionally high at 36. Over 60% of the benefits were experienced by properties within 500m of the park.
- The proposed Duong Dong Freshwater Wildlife Conservation Park in Phu Quoc Vietnam would provide benefits to tourists and residents (CRCWSC and ICEM, 2021d). Total costs were

USD29.6m using a hybrid approach, with over half spent on civil engineering for a retaining wall and substantial amounts on land acquisition and a waste recycling facility. Over 70% of the benefits came from flood protection for communities outside the park and 10% form biodiversity. Smaller benefits came from amenity for residents and tourists and from waste recycling. The overall BCR was 3.3, which is above normal public expenditure requirements but is much lower than the other case studies, perhaps reflecting the expense of the project and the less dense population.

In all the Mekong case studies, the potential financing sources included: scaling up of project financing, private investment and a growing green finance system. The Rayong and Doung Dong studies also suggested that there were options for raising fees and taxes on enterprises benefiting from GI and for using public funds for incentives for the private sector to participate in financing GI.

The draft synthesis report highlighted the following key points.

- The retreat-adapt-defend approach was successful in identifying a package of NbS actions, including large parks, smaller assets, linear assets, catchment scale perspectives, water cycling and circular economy actions.
- The NbS actions demonstrated a wide range of benefits.
- Implementation of NbS actions can involve a wide range of public, private and community partnerships.
- Better understanding of costs and benefits can help deliver more inclusive ownership and more efficient, effective and fair outcomes and financing arrangements.

4.3 Benefit Cost Ratio

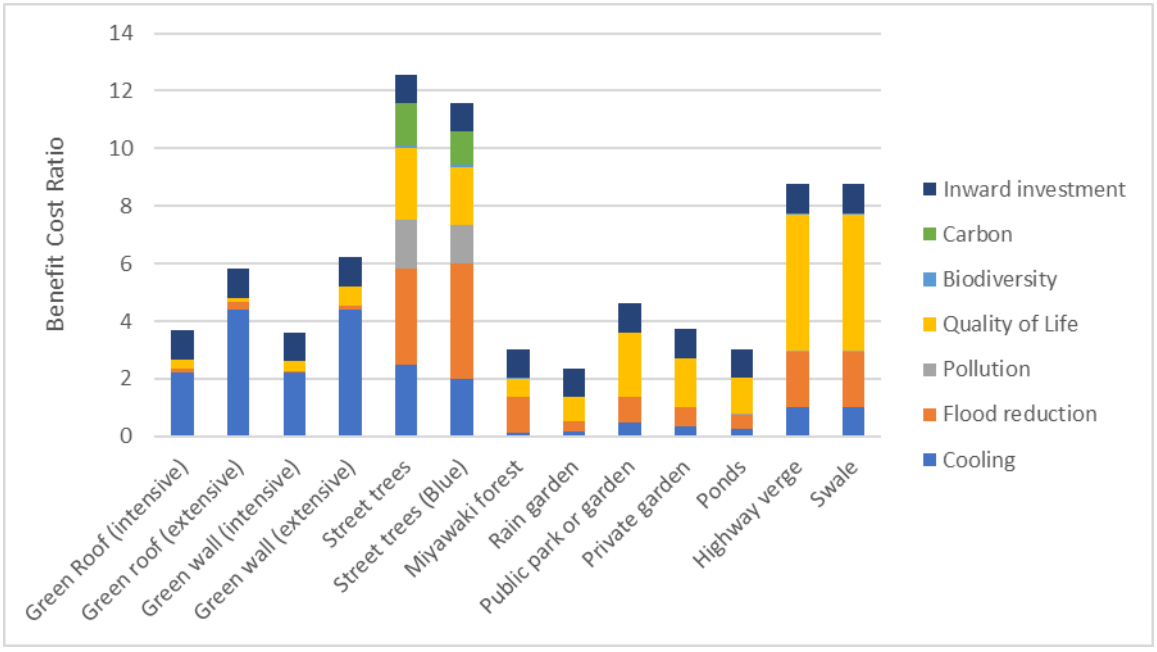
Synthesis of evidence on unit costs and benefits. The evidence described above is used to prepare estimates of indicators values for the unit costs and benefits of GI actions, as presented in Table 9. Clearly, the actual costs and benefits will vary greatly, depending on the circumstances at each individual GI site and the values in Table 9 are only indicative. The evidence for many of the values comes from international work and, although adjustments have been made to try to reflect differences in the economic situation in Cambodia, further work is needed to refine the estimates.

Table 9 Unit costs and benefits used in the economic analysis

	GI Actions	Scale Unit	Unit Net Costs ($/unit)					Benefits ($/unit/yr)							BCR
			Private		Public		Total	Cooling	Flood	Pollution	Life	Bio	Carbon	Invest	
			CAPEX	OPEX	CAPEX	OPEX	10 yrs								
	Green Roof														
1	Green Roof (intensive)	m^2	100	5.0			150	33.00	2.0	0.015	5.0	0.04	0.00	15	3.7
2	Green roof (extensive)	m^2	75	0.0			75	33.00	2.0	0.015	1.0	0.04	0.00	7.5	5.8
	Green Wall														
3	Green wall (intensive)	m^2	100	5.0			150	33.00	1.0	0.015	5.0	0.04	0.00	15	3.6
4	Green wall (extensive)	m^2	75	0.0			75	33.00	1.0	0.015	5.0	0.04	0.00	7.5	6.2
	Trees														
5	Street trees	tree			20	1.0	30	7.50	10.0	5.0	7.5	0.30	4.40	3	12.6
6	Street trees (Blue)	tree			25	1.3	38	7.50	15.0	5.0	7.5	0.30	4.40	3.75	11.6
7	Miyawaki forest	m^2			30	5.0	80	1.07	10.0	0.03	5.0	0.04	0.04	8	3.0
	Park and Garden														
8	Rain garden	m^2			30	3.0	60	1.07	2.0	0.03	5.0	0.04	0.00	6	2.4
9	Public park or garden	m^2			15	0.8	23	1.07	2.0	0.03	5.0	0.04	0.00	2.25	4.6
10	Private garden	m^2	20	1.0			30	1.07	2.0	0.03	5.0	0.04	0.00	3	3.7
11	Ponds	m^2			20	2.0	40	1.07	2.0	0.03	5.0	0.04	0.00	4	3.0
	Verge														
12	Highway verge	m^2			7	0.4	11	1.07	2.0	0.03	5.0	0.04	0.00	1.05	8.8
13	Swale	m^2			7	0.4	11	1.07	2.0	0.03	5.0	0.04	0.00	1.05	8.8

The standard unit costs and benefits in Table 9 can be used to estimate typical values for the BCRs of individual GI actions, as presented in Figure 8. These are not definitive estimates of BCRs but rather the results of an analytical framework that provides yardsticks against which real planning can take place, with work on site-specific costs and benefits being compared with the yardsticks in Table 9. The figure suggests that all the GI measures do deliver attractive BCRs of over 2.0. Trees and verges are particularly attractive, with BCRs of over 8.0.

Figure 8 Benefit cost ratios of GI actions



4.4 Beneficiaries: government, developer and public

Enterprises. The benefits for enterprises are derived from profits from inward investment and from higher housing values. Net benefits are estimated after deducting 20% corporation tax.

Inward investment generates valued added that comprises incomes to households and profits. It is assumed that 25% of the value-added arising from the inward investment is profit.

There are also profits for enterprises that own property near GI assets. The analysis uses evidence from 20 studies on the impact on house prices within 100m of a park or wood. The average for the studies is USD 16,000. As the studies are almost entirely in developed countries, the analysis assumes the impact of a park in Phnom Penh will be half this level. Given the average population density in Phnom Penh, there are about 100 houses within 100m of a 1ha park. These assumptions suggest that every m^2 of park will lead to an increase of USD 83 in property value. It is assumed that half of this property is owned by enterprises who charge rent at 5% of the property value, of which 40% is profit.

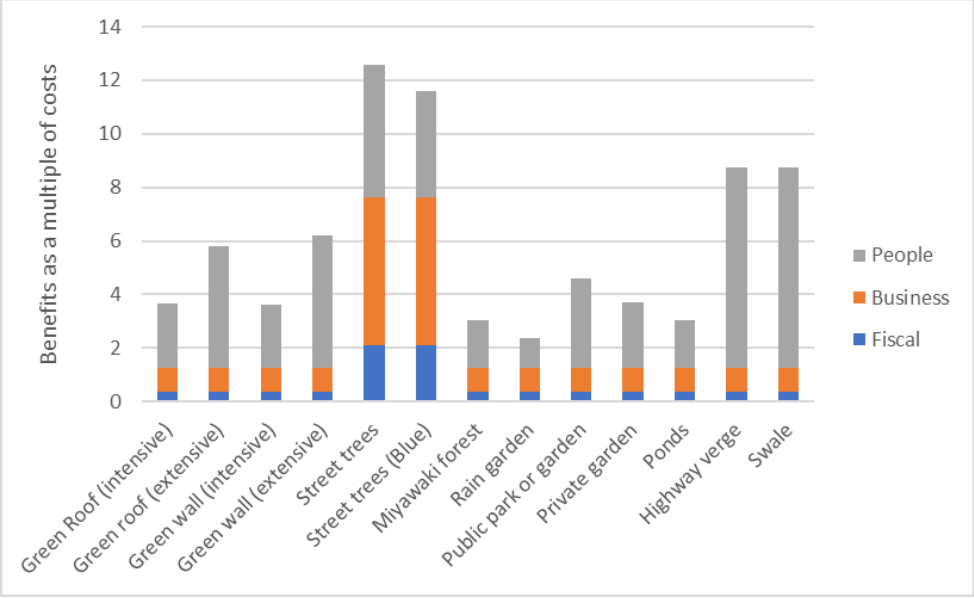
Fiscal benefits. There are substantial tax benefits from investing in GI, including the following key taxes.

- *Tax on Immovable Property (TOIP).* TOIP is assumed to be charged at 0.1% on the increased value of property close to GI, as described above.
- *Income tax.* It is assumed that 75% of the value added from increased inward investment is incomes and that these are taxed at 10%.
- *Corporation tax.* It is assumed that corporation tax is charged at 20% on the increased profits to enterprises described above.

Benefits to residents and workers. The remaining benefits are experienced by the population that live and work in the city.

The overall distribution of benefits amongst government, enterprises and residents/workers in the city is presented in Figure 9. The distribution of benefits varies with the GI asset but is split roughly equally between enterprises and residents/workers, with fiscal revenue accounting for a relatively small share.

Figure 9 Distribution of benefits amongst beneficiaries



4.5 Phnom Penh GI scenario

There is no inventory of GI space in Phnom Penh. The analysis and mapping of vegetation cover in section 2 provides an overall indication of the vegetation but does not specify the breakdown of the types of vegetation of types of GI asset. The analysis in section 2 does suggest that the level of GI in the 10% of Phnom Penh that can be classed as continuously built-up is very low in comparison with the built-up area in other Southeast Asian cities and that it may be necessary for Phnom Penh to integrate GI into over 20% of the built-up area to catch up with other cities in the region.

This section presents two scenarios for GI expansion in Phnom Penh. The moderate scenario is defined by an expenditure level that rises to about USD 50m over 10 years. The ambitious scenario has expenditure of USD 80m over 10 years but is also characterised by a more rapid implementation of policies that promote and require private sector investment, so that most of the additional costs are born by the private sector.

The moderate scenario expands the green area by 2395ha over the 10 years, which is only 3.5% of the total administrative area, but about one third of the continuously built-up area, as defined in chapter 2. The scenario does not specify where assets will be located, which will depend on space available and the demand from the private sector. However, the scenario does specify the growth in each of the assets, with the following total levels of GI assets in Y10:

- 120 ha of green roofs, one third of which are extensive
- 30 ha of green walls, one third of which are extensive
- 1.12m trees, of which 0.32m are in pits, plus 1000m2 of Miyawaki forest
- 1000 ha of parks and gardens, of which half are public and half private
- 10 ha of rain gardens and 10 ha of ponds
- 100 ha of verges and swales and 5ha of channelised rivers/streams

The scenarios focus on the direct costs and benefits of investing in GI assets. A detailed costing has not been made for the work required for the design, piloting, implementation and enforcement of supporting policies and regulations. The final chapter recommends some indicative lump-sum budgets for this work.

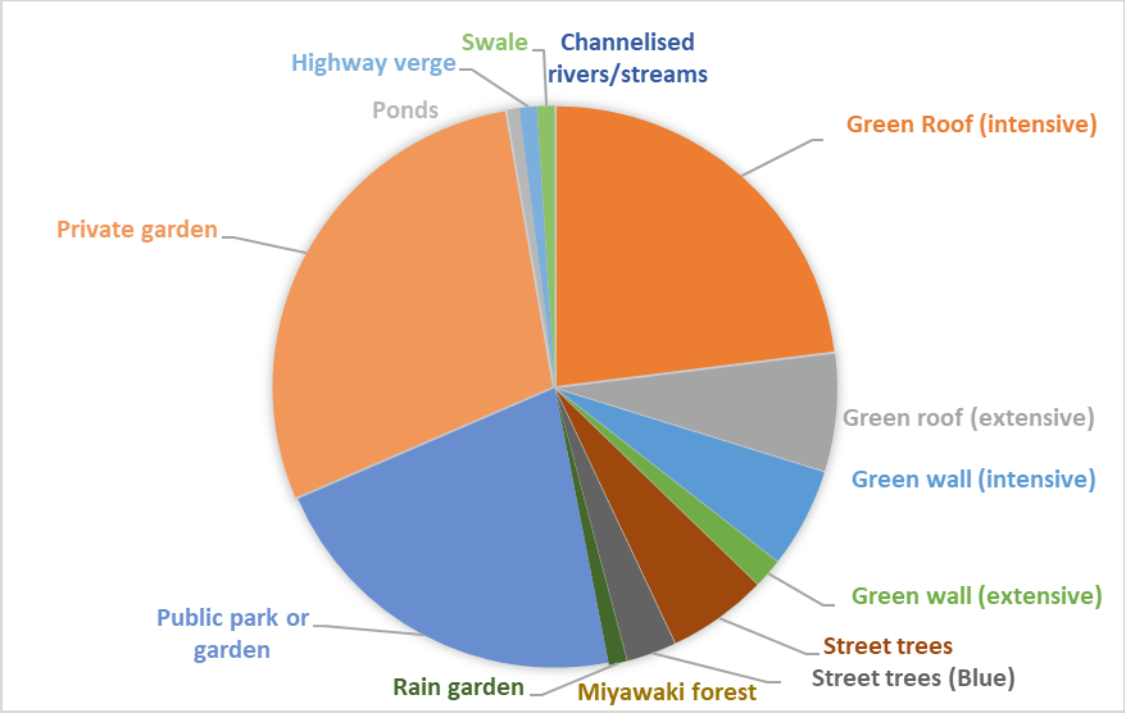
Total costs of the moderate scenario. Table 10 summarises the costs of the moderate scenario. By Y10, public investment is USD 111.7m per year and private investment is USD 23.8m. Maintenance costs to an estimated level of USD 6.1m for the public sector and USD 10.0m for the private sector. The total costs over the 10-year period are USD 443m, of which 34% (e.g., USD 150.6m) are met by the public sector.

Table 10 Costs of the moderate scenario (USD million)

Costs (USD million)	Y1	Y5	Y10	Total (10 years)	Total (%)
Public investment	11.7	11.7	11.7	117.0	26.4%
Public maintenance	0.6	3.1	6.1	33.6	7.6%
Private investment	23.8	23.8	23.8	237.5	53.6%
Private maintenance	1.0	5.0	10.0	55.0	12.4%
Total	37.1	43.5	51.6	443.1	100.0%

Most of the costs are devoted to public and private parks and gardens, with substantial expenditure on green roofs and green walls, as described in Figure 10.

Figure 10 Composition of costs over 10 years



Benefits. The total benefits of the PPGI scenario are estimated by multiplying the scale of the GI assets by the unit benefits. The results are summarised in Table 11, which shows that benefits associated with cooling and with improved quality of life each account for about 29% of total benefits. Value added from increased inward investment is also important (with 20.5% of total benefits) and flood protection accounts for 16.3% of benefits. Other benefits are small.

Table 11 Value of benefits in each year (USD million)

Benefits (USD million)	Y1	Y5	Y10	Total (10 years)	Total (%)
Cooling	7.2	36.0	72.0	395.9	28.6%
Flood protection	4.1	20.6	41.1	226.1	16.3%
Pollution reduction	0.7	3.7	7.4	40.5	2.9%
Quality of life	7.2	36.2	72.4	398.2	28.8%
Biodiversity	0.1	0.5	0.9	5.1	0.4%
Carbon sequestration	0.6	3.1	6.2	33.9	2.4%
Value added from FDI	5.2	25.8	51.6	283.6	20.5%
Total	25.2	125.8	251.5	1,383.3	100.0%

Figure 11 describes the composition of the total benefits of the PPGI scenario over 10 years. All GI assets contribute to the benefits of value added generated by increased FDI. Cooling benefits come primarily from green roofs and green walls, although some cooling benefits are also derived by residents near parks and gardens. Flood protection is provided primarily by the large areas of parks and gardens, which are also the main source of improved quality of life.

Figure 11 Composition of benefits by GI in the PPGI scenario (USD million, 10 years)

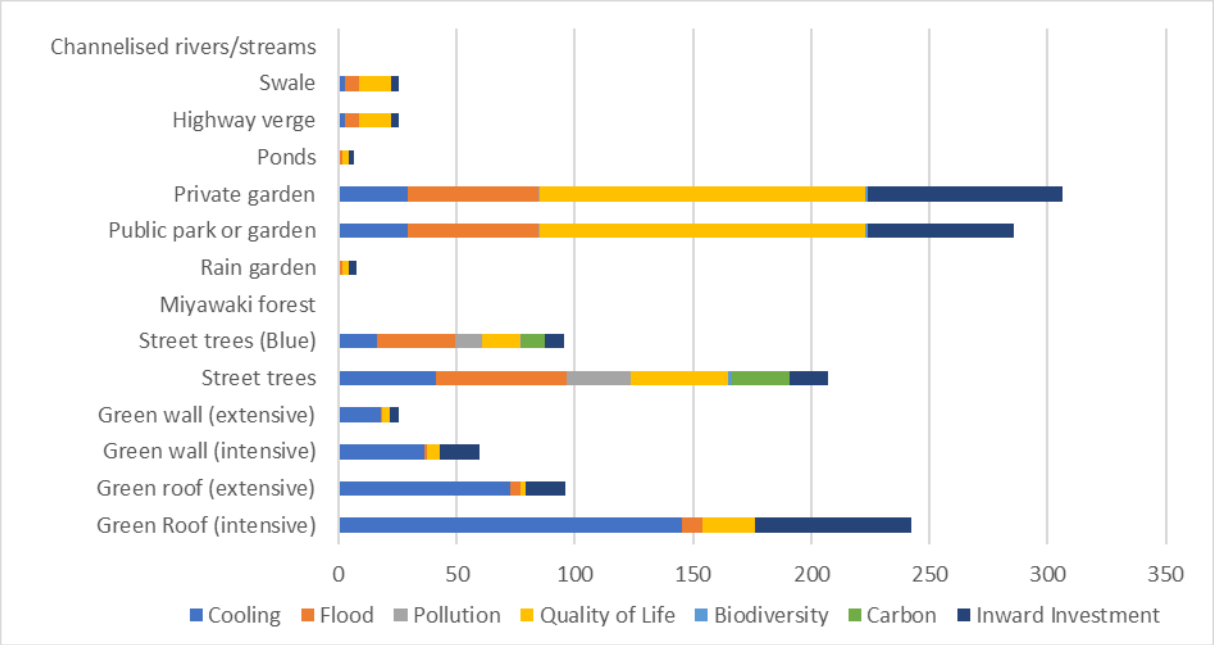
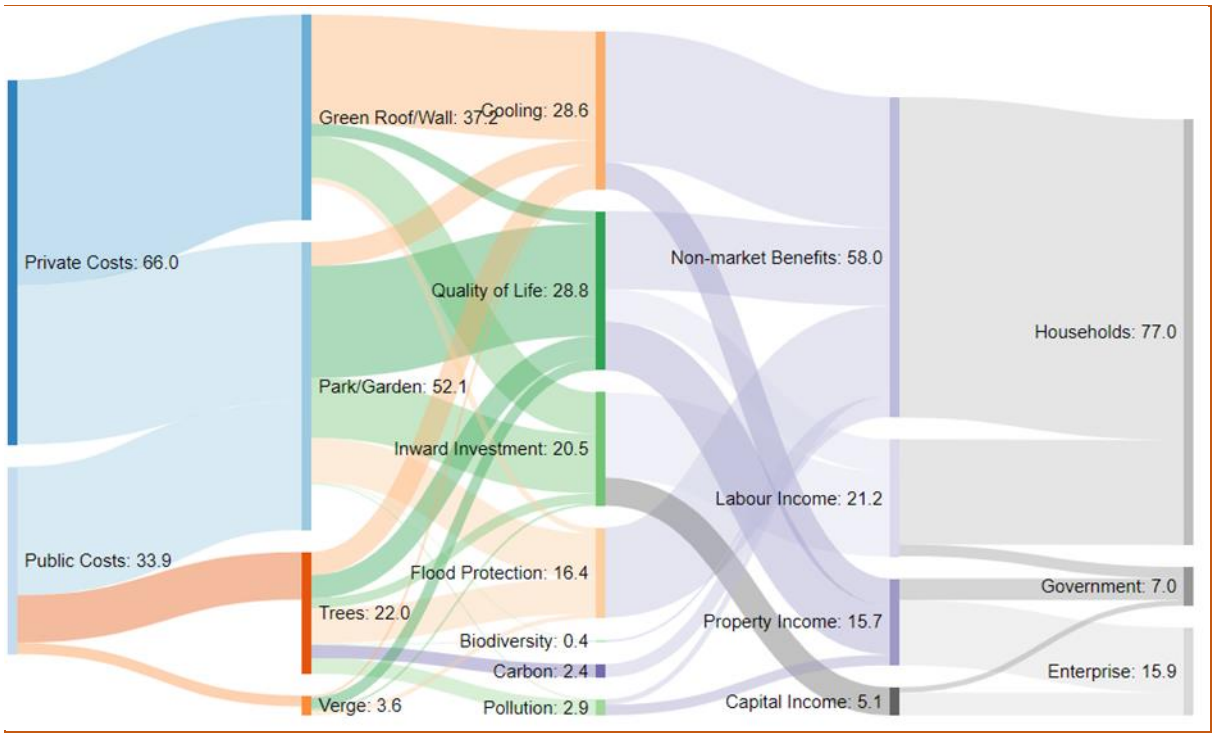


Figure 12 presents the flow from investors to GI assets to benefits. Numbers refer to the percentage of costs or benefits. Labour, property and capital income have a direct impact on value added and GDP. Other benefits are non-market benefits which are not captured directly in GDP. However, they will still have an indirect impact on GDP notably through improved health and productivity (associated with cooling and quality of life) and reduced loss and damage from reduced flooding.

Figure 12 Benefits from moderate scenario (% of costs/benefits)



Notes: the leftmost bar is the proportion of costs (investment and O&M) over 10 years; all other bars are the Net Present Value of all benefits arising from investment over 10 years. Trees have a higher share of benefits than costs because they have a significantly higher Benefit Cost Ratio

Net Benefits. Figure 14 compares the costs and net benefits of the PPGI scenario. By the end of the period the value added generated by additional Foreign Direct Investment (FDI) cover the investment and maintenance costs of the GI. The total value of all wider benefits is similar to the economic benefits and the net benefits after ten years are about USD 80m per year.

Figure 14 Costs and benefits of the PPGI scenario

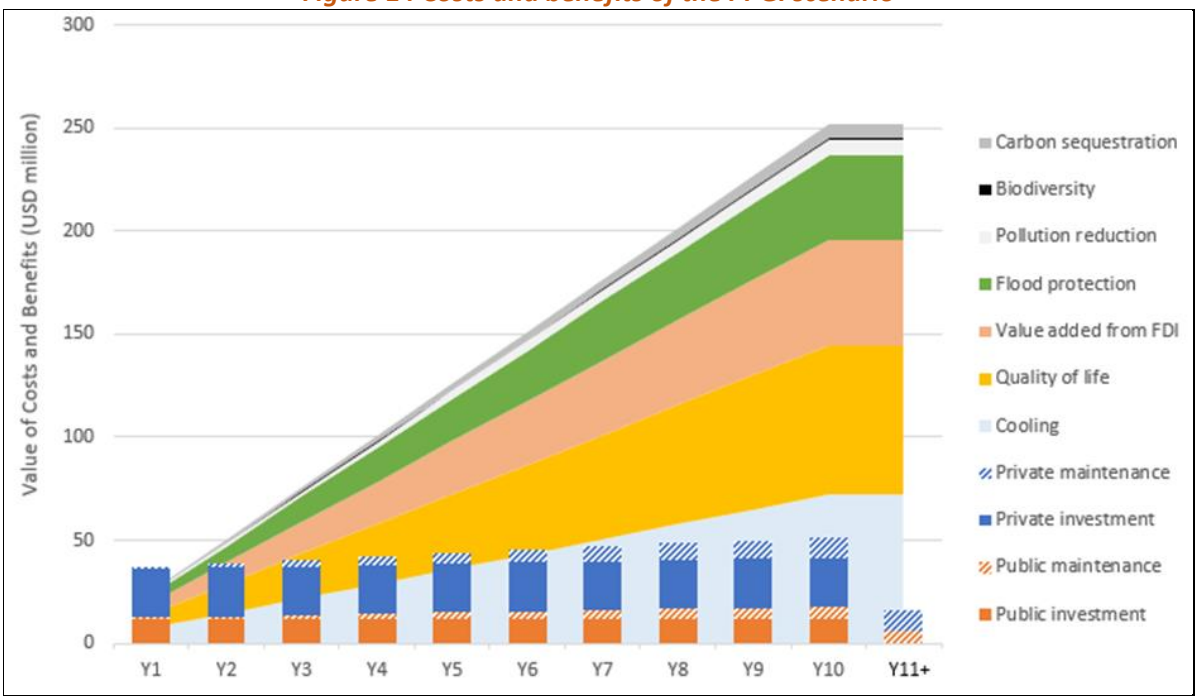
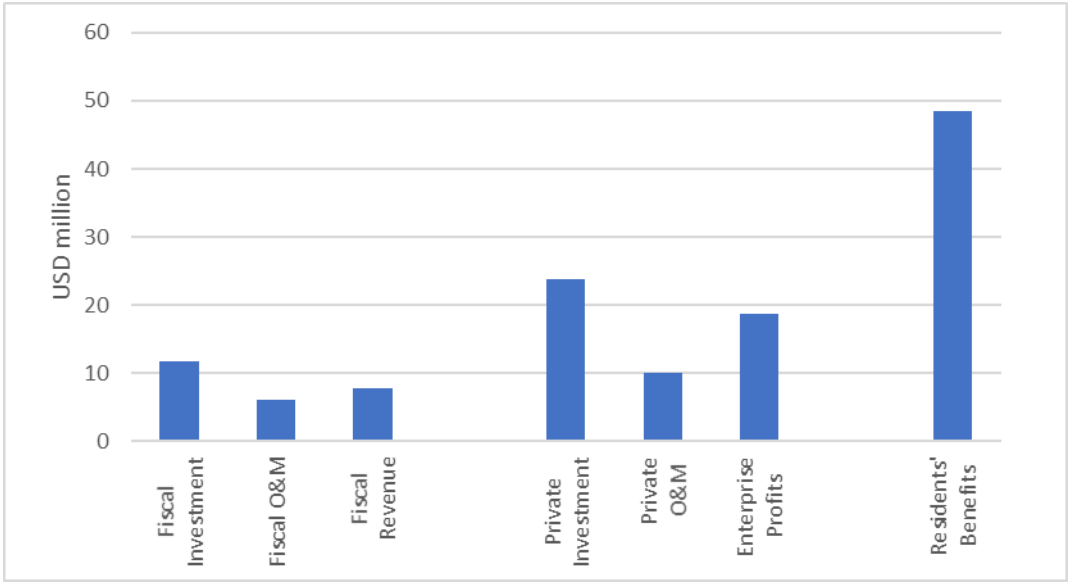


Figure 13 shows the annual costs and benefits for the public and private sectors, as well as for residents and workers in the city in the tenth year of the scenario. The figure shows that the revenue is slightly higher than the annual O&M costs for the public sector and nearly double for the private sector. The investment in the scenario is a 10-year programme which delivers fixed GI assets that are then sustained indefinitely beyond the tenth year, provided that sufficient O&M is continued. Thus, for years eleven onwards, there will be a continuing modest net benefit stream for the public sector and a substantial net benefits stream for the private sectors. The majority of the benefits are received by residents and workers in the city, both in Y10 and in subsequent years.

Figure 13 Annual costs and benefits in Y10 for the public and private sectors and residents



Ambitious Scenario. The moderate scenario is, to a large extent, scalable and the extent of GI infrastructure could be 50% greater or 50% less by Y10. An ambitious scenario with 50% more GI assets would seem to be roughly consistent with bringing Phnom Penh up to the best standards of the region. The way in which this could be achieved, give the current layout of the city needs to be examined in more detail.

Given the limits on government budgets, the scale of the expansion of GI will depend heavily on the expansion of private investment and innovative funding mechanisms. This will require a substantial political and financial commitment by government to the design, piloting and implementation of incentives and regulations that encourage or require the private sector to fund GI and that facilitate innovative financing options, as described in the final chapter. This commitment will require a significant budget, with spending of perhaps as much as USD 5m over about 4 years. This investment in policy is worthwhile, even if investment in GI is 50% slower than in the moderate scenario. However, if the investment in incentives and policy is successful, then it should be possible to achieve a more ambitious scenario.

Investment in urban GI usually accelerates as public awareness increases and demand becomes more vocal. Storyboards have often been used in campaigns to promote awareness of urban GI, with a view to building demand for GI. Figure 14 presents a typical story board. The top two images represent an ambitious scenario, with the first showing GI along riparian corridors in the city, combined with good governance, and the second representing equality and diversity in access to GI. The bottom images represent a business-as-usual scenario with flooding and drought, combined with rapid sprawl of informal settlements and investment in grey infrastructure.

Figure 14 'Storyboard' visualisation of the benefits of faster adoption of GI

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Source: Thorn et al. (2022)

5 Financing and policy framework

This chapter describes the main sources of financing that are available to provide the funds for the investment in GI that will be needed to implement the expansion of GI. It then suggests a possible financing framework, with target levels of funding from each of the main sources of finance. Finally, it describes the main supporting policies that need to be in place if the investment is to be effective.

5.1 Public sector financing mechanisms

Public expenditure from the budget. Public expenditure by national and local government often provides the largest proportion of funding for urban GI. However, there is very little evidence about the scale of public funding for urban GI, especially in SE Asia. It is clear that GI accounts for a small element of municipal budgets and local authorities lack the resources and expertise for scaling GI, even when it receives strong public and political interest. A review in the US found that the share of State budgets on parks and recreation fell from 0.54% to 0.31% between 2000 and 2014, which is a drop from 24 to 15 $/person. No comparable evidence has been found for SE Asia, but it seems clear that municipalities are likely to be under similar budget pressures. In Phnom Penh, total public expenditure is about USD 195m (or 130 $/capita), which suggests that much smaller levels of funding could be available from within the City Hall budget (Rath 2019).

Relevance for Cambodia: The budget will remain an important source of funding for public GI. This will not be a net burden on the budget because tax income should increase roughly in line with the O&M of public GI.

International green finance. The Paris and Glasgow agreements on climate change have established commitments by developed countries to provide USD 100bn of additional finance to developing countries for climate related expenditure every year. Similar commitments are being sought at COP15 of the UN Conference for Biological Diversity (UNCBD), which is being held in Kunming in China in October 2021 and April/May 2022. The funds committed are being provided through a wide range of channels, including the Green Climate Fund, various initiatives managed by MDBs and bilateral funding. Municipalities should therefore be able to apply to international green funds for programmes of investment in GI. The ability to demonstrate benefits related to climate adaptation, climate mitigation and biodiversity is an essential part of applications to these funds. One example of international climate finance is the USD 558 million Pilot Programme for Climate Resilience of the Climate Investment Funds, supported by the Asian Development Bank in Cambodia (ADB, 2021). In some cases, intergovernmental grants can help compensate cities for the opportunity cost of installing and maintaining GI (e.g., the loss of development charges if an area is designated as a public park). Matching grants can further compensate local governments for the spill overs generated by GI that incur localised costs but generate broad benefits (Mark, 2012). Natural capital accounting can help bring out the multiple benefits from GI when calculating the return on investment (Thorn et al. 2021).

Relevance for Cambodia: There is strong interest amongst international partners and green finance institutions for providing finance for urban GI.

Tax. Tax Increment Financing (TIF) is a tool is used to redevelop areas in need of brown field remediation or revitalization – with positive impact on urban quality of life and future tax revenue. To kick-start the redevelopment, the municipality or redevelopment agency invests in infrastructure and/or acquires land, usually funded through borrowing or issuing bonds against the expected incremental tax increases (TIF bonds) and then TIF funds are used to pay back these bonds. TIFs are generally governed by state/provincial legislation and are thus applied differently depending on the context. This tool was introduced in California in 1952 and has spread to all states in the US. In 2005 in Chicago. 10% of all property taxes were earmarked for TIF purposes and TIF districts covered more

than 25% of the city's geographic area (Quigley, 2007). However, some critics argue this approach for stimulating GI investments has morphed from a tool for inner-city revitalisation into a widely used suburban program which can result in sprawl (LeRoy, 2008). Another approach used widely by governments, especially throughout the OECD is property taxes for GI (Mark, 2012). Actions taken removing policies that favour single-family homes over multi-family properties result in less dense developments. When property taxes are based on land value, rather than buildings or other improvements to the property, owners are incentivised develop the land to its most profitable use. Replacing a traditional property tax with a land-value tax, or a split-value tax that includes higher rates for land value and lower rates for structures or other improvements encourages densification, as shown in the case of some municipalities in Pennsylvania, USA. Selling additional building rights is another means to authorise higher-density development, as shown in the case of São Paolo, Brazil and Maharashtra, India where the maximum floor space was increased. Imposing area-specific charges where there is a one-time levy on developers to finance growth-related infrastructure investments needed to serve the new development or redevelopment is an effective planning tool and compensation to correct for the external costs for a development, eg the metro-line in Copenhagen was financed through fees from development of Ørestad, Copenhagen (OECD, 2009).

Relevance for Cambodia: Property taxes can be used to help limit urban sprawl into green and blue spaces, while tax increment financing stimulates private investment in urban cores and assists these areas to compete with outlying suburban and exurban areas.

User charges. Another common mechanism to secure revenue for GI is user charges, particularly when there is insufficient revenue from national government – and can take make multiple forms. Transport or congestion charges have been shown to be effective to finance GI and less costly to users when differentiated according to the level of congestion, peak hours, or both; linked to vehicle type and emissions; increasing alternative mobility solutions (e.g., public transport, cycling, pedestrian routes) and with coherent planning (Mark, 2012). Another approach is development charges impact fees) and value capture (taxes that capture the value increases of real estate due to new infrastructure development nearby_ where real estate developers pay for the infrastructure that is needed to connect their new development to existing infrastructure. Third, charges can help stimulate responsible water consumption – based on actual use of users. Here, fees and prices signal the actual level of resource scarcity and cover the costs of infrastructure investment and service provision. Fourth, carbon-offsetting programmes include the Clean Development Mechanism, Joint Crediting Mechanism and voluntary carbon offset among other approaches. A critical element of carbon offsetting is having a harmonised emission inventory for cities. An example of this is eco-tourism is a tool which has been employed in Kao Tao in Thailand. Another approach in Thailand has been where the Thai government administers the distribution of special license plates which are sold at a premium to support conservation.

Relevance to Cambodia: There should be opportunities for the collection of some user charges from businesses that are granted licenses for using public parks. Cambodia can also consider earmarking some taxes for investment in GI (e.g., transport charges, development charges, value charges and water consumption charges) which could help to build public awareness, interest and acceptance of GI and of taxes.

A recent review of GI policies in 113 cities in 19 countries considered the range of incentives for constructing more green roofs and green walls (Liberalesso 2020). Green roofs and green walls have the higher cost per m^2 of all GI assets and, although they also have high benefits (especially from cooling), they are sensitive to incentives. The study concluded identified 143 incentives in the 113 cities, including: tax reductions (23 cases, relating to property taxes, stormwater fees and other utilities); subsidies and reduced interest rates (80); construction permits (6); sustainability certification

(10); legal obligation (22); and 'agile administrative processes' (2). Most of the cities were in Europe and North America. Asian cities were in China, Japan, Singapore and South Korea.

5.2 Private sector financing mechanisms

Private investment for profit. The economic analysis in section 4 suggests that it is profitable for private developers to invest in GI assets even if there are no incentives and regulations to influence their investment decisions. The consultation with key informants suggested that some developers in Phnom Penh are already aware of the potential returns from incorporating GI into developments and some developments will therefore include GI assets regardless of the incentives and regulations in place. However, many developers will continue to focus on short term gains and to minimise investment costs and the pace at which GI expands will be limited, without public policy.

Box 4 Elephant Park private investment in GI assets

A good example of a private investment in urban GI is provided by the Elephant Park scheme in Central London[9]. The GI assets include 1200 trees and a new public park of about 1ha, which is the largest new green space created in London for 70 years. Financing is provided entirely by the private sector and is associated with investment for 3000 new homes (of which a quarter are 'affordable housing'), 50 new enterprises (including shops, cafes and restaurants) and about 5000 m2 of workshop space. The scheme also includes infrastructure for cycling and renewable energy, which will make the development to first 'climate positive' development in the UK.

The motivation for including GI assets in the private investment comes from three main sources: a) facilitation of planning approval by aligning the development with planning policies on greenspace, biodiversity and climate resilience); b) profitability arising from increased property values near the green spaces; and c) philanthropic commitment of the developer to their own sustainability agenda.

Impact investment. Impact investments (II) are 'made into companies, organizations and funds with the intention to generate social and environmental impact alongside a financial return' (GIIN, 2018). They include green bonds (see below), which focus on climate change and environmental impact, but are broader in scope and include social impact. Funding typically comes from financial institutions, pension funds, foundations and individual philanthropists looking for greater transparency and some return, supported both by ethical concerns and the belief that investments deliver social and environmental benefits are likely to be more reliable and subject to fewer risks. Urban GI is well suited to impact investment because of the wide range of benefits. The strong growth in supply of potential investors and experience with managing II means that there should be potential to utilise II for urban GI. However, this is likely to be relevant only to private investment in urban GI, because investors do expect a return on their capital.

A review if impact investment in Southeast Asia found that 90% comes from Development Finance Institutions (DFIs) and Cambodia ranks 6th amongst 10 SE Asian countries in the level of II from DFIs that it receives (GINN, 2018. However, Cambodia ranks first in the region in private II (PII), with 45% of the total PII in the region. This is almost all accounted for by microfinance institutions that deliver social benefits. The report concluded that the main challenges are associated with a lack of an investible pipeline; limited local experience; dependence on grant elements to support financial returns. The main opportunities were associated with accessing local dormant capital; diversifying into new sectors; building experience and evidence of success; and linking SE Asia with international sources of impact investment. With Cambodia's strong experience in accessing impact investment for the micro-finance sector, there would seem to be good prospects for raising finance for private investment in urban GI.

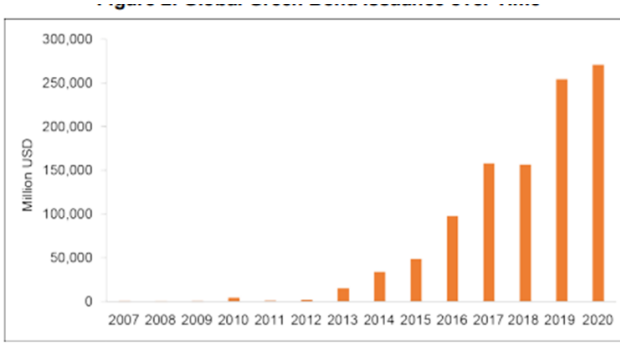
[9] https://www.elephantpark.co.uk/about-elephant-park/project-vision/

The GIIN study did also identify some 'ecosystem' challenges and opportunities which are important to recognise when considering the potential of impact investment for urban GI. The first challenge is the need to demonstrate financial returns, which suggests that any use of impact investment for urban GI would need to be linked to other measures (e.g., fees from businesses using the GI, a share of any increase in property rents or taxes and a contribution from philanthropic sources). Other ecosystem challenges include the need for capacity building and the need to avoid policy 'roadblocks', both of which Cambodia should be well placed to address.

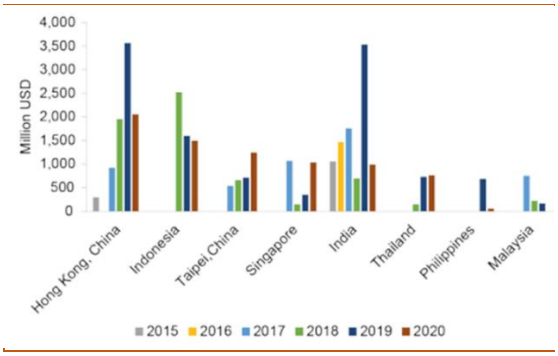
Green bonds and loans. Green bonds are used to fund government activities, parastatals and private enterprises. A recent review by the ADB Institute suggested that governments accounted for 17% of green bonds in Asia and utilities for 13% (Azhgaliyeva, 2021). Financial institutions accounted for 50% of bonds issued and the remaining 20% were used to finance private enterprises. Although green bonds are often considered as options for funding renewable energy and green transport, the study suggested that 43% of all green bonds were used to finance green buildings, suggesting that green bonds are well-suited to funding urban GI. The ADBI reviewed the policies that were most effective at facilitating green bond growth in ASEAN countries and concluded that the most effective policies were: grants linked to green bonds; tax incentives; and cooperation, especially at a regional level.

Provide institutional investors, such as pension funds, stable yields and limited risks whilst also enabling them to pursue ethical investment objectives (Della Croce et al., 2011). Green bonds are fixed-income securities issued to raise the necessary capital from institutional investors for GI. SRI Sukuk and Bond Grant Scheme was one of the first global examples of incentive structures to support green bond issuance (Climate Bonds Initiative, 2021).

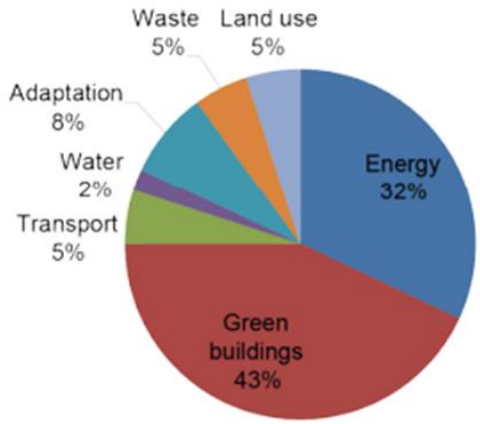
Figure 15 Green bond issuance in Asia (excluding PRC, Japan and South Korea)



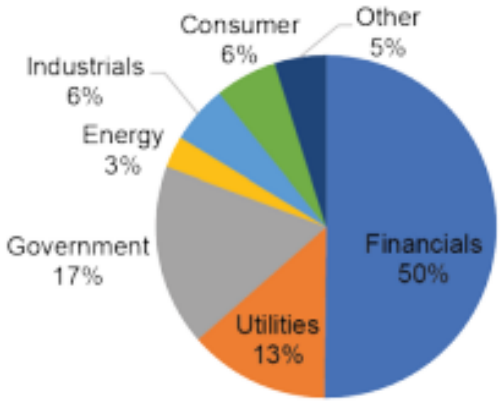
Global Green Bond Market



Asian Green Bonds excluding PRC/Japan/Korea



Sectoral Composition of Green Bonds in Asia



Green Bonds by Industry in Asia

Source: Azhgaliyeva (2021)

The more revenue sources a city has, the higher its perceived repayment capacity and thus the greater its access to debt markets, including loans. Therefore, if sound financial management subject to prudent local regulations, if sub-national local and central governments access to loans increase there is the potential to scale GI.

Relevance to Cambodia: Greater access to loans and bonds helps to mobilise finance GI investments and can help attract private finance in a well-functioning capital market.

Philanthropic initiatives. These may involve community, banks, companies, trust funds and schools. For example, the Green City Fund is registered charity established in 2002 in Singapore is one example of a financing model and charity which was set up by the National Parks Board. The aim is to optimise the use of green spaces, support an urban biodiversity conservation model, engage communities and enhance the competencies of the landscaping industry in Singapore. Individuals, as well as companies donate to plant trees. For instance, the Jacob Ballas Trust Fund supported the establishment of the first children garden. The Shaw Foundation supported symphonic stage for musical performances. Communities and schools support the Plant-A-Tree programme and the bank HSBC supports a programme to encourage volunteerism through the Volunteer Hub. The Asia Pacific Breweries and others support a programme on marine conservation. Who Hup (Private) Limited, one of Singapore Largest private construction groups supported the Therapeutic Garden. This in turn generates revenue through attracting tourism.

Relevance to Cambodia: Philanthropic initiatives can be used to support conservation, research, education and outreach.

Income generating opportunities. Green spaces offer strong business opportunities, including sports facilities, restaurants and cafes, festivals and other events. Whilst these need to be managed sympathetically, to avoid diluting the sense of freedom and community spirit, there are opportunities to meet at least some of the operation and maintenance costs of GI from rents or sponsorship. Some cities have used 'Special Purpose Funding Vehicles' (SPVs) to coordinate the financing of urban GI, allowing a mix of borrowing, sponsorship and grants to be mobilised for a GI initiative that has strong public support (CABE 2006).

Relevance to Cambodia: Combining green spaces with underground parking may have potential in some areas of Phnom Penh, especially in central areas where the value of land and demand for parking is high. Some existing examples already exist, including the underground parking at the public park between Vattanac Capital and Canada Tower, financed by investment from private companies[10].

5.3 Public-Private Partnerships (PPPs)

Broadly defined, PPPs are long-term contractual agreements between a private operator/company (or a consortium) and a public entity, under which a service is provided, generally with related investments (Saussier et al., 2009). Blended financing through PPPs covers a diversity of contractual agreements characterised by different risk-sharing, financing schemes, organisational forms and involve a range of actors with different interests. Unlike traditional public sector procurement, PPPs involve a process in which private operators bid for a contract to design, finance and manage the risks involved in delivering public services or assets. In return, the private contractor receives fees from the public body and/or user tolls for the long-term operation and maintenance of the asset. PPPs can be solicited or unsolicited, depending on who initiatives the partnership. For GI, several best practice

[10] https://construction-property.com/more-underground-parking-lots-needed-in-phnom-penh-amid-rapid-growth-in-vehicles/

projects by the C40 are governed by PPPs such as waste management in Sydney, Australia; bicycles paths in Bogota, Colombia; and water distribution in Emefuloni, South Africa (Mark, 2012).

Relevance to Cambodia: As far as this study is aware, all urban GI assets in Cambodia have been funded either by the public or the private sector and there are no examples where investment and/or O&M are jointly financed. However, the strong private sector in Cambodia, and the good reputation of the government with private sector investors, suggest that there should be good opportunities for PPP in Cambodia.

Box 5 Innovative Finance Lab for sustainable infrastructure in Southeast Asia

In October 2019, the Asian Development Bank (ADB) and Infrastructure Asia, in Singapore, set up an initiative to provide innovative financing approaches for GI (ADB 2021). The objective is to provide technical support to enable municipalities and state-owned enterprises to access private capital for GI investments. The primary vehicle for this initiative is the Innovative Finance Lab, which is a virtual space for exchange, capacity building and fostering new green finance models for GI. The Lab also helps government access the ASEAN Catalytic Green Finance Facility (ACGF), which is part of a wider Green and Inclusive Infrastructure Window launched by SE Asian governments, ADB and international partners as part of the ASEAN Infrastructure Fund.

5.4 Financing framework

The total costs of the Phnom Penh GI scenario are presented in section 4.5, broken down by the costs of each of the assets and the division between public and private financing.

A range of financing models are emerging to scale GI in Southeast Asia, some examples of which have been described in this chapter, along with their potential relevance to Cambodia. There will remain needs and opportunities for the public sector to investment in public GI, but there are also huge opportunities for new financing instruments and for private sector engagement in private GI assets and for public private partnerships. A recent assessment of global GI needs, suggested that about USD 100 trillion of climate compatible infrastructure by 2030 is needed (Climate Bonds Initiative 2021).

Financing mechanisms that have shown success are those which are complementary and promote a combination of systemic and local financing, policy changes and other incentive mechanisms. Key to any financing model is not only generating revenues, but enhancing effectiveness and delivery, coordination and integration, realigning expenditures, partnerships and internalizing externalities – whereby any costs, fees or charges are designed to confront agents with the full marginal social costs of actions effecting the environment and social equity. In all cases, it is important to have wide-ranging feasibility analyses and consultations.

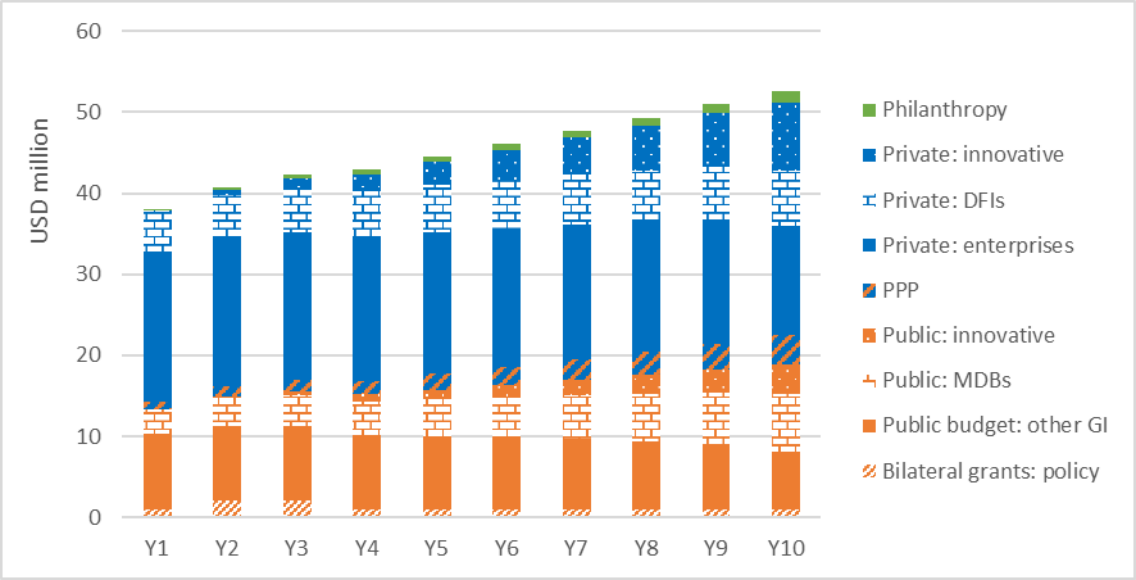
This chapter has reviewed the potential roles in Cambodia of the main sources of finance. Figure 16 summarises this by presenting an illustrative framework for 10 years with the following key features.

- Modest but significant expenditure is required for design, piloting, implementation and enforcement of plans and policies. This will come from public funds and it should be possible to find grants from international partners to fund this work.
- Funding from the public budget is assumed to be roughly USD 10m and to continue at roughly this level for most of the period, with a slight decline towards the end as innovative and private sources become available. By the end of the period, much of this will be devoted to funding

the O&M of public GI assets. The analysis in section 4.4 suggests that tax revenue will increase by slightly more than the additional costs of O&M.

- There is strong interest amongst MDBs who will provide steadily growing level of financing for GI investment.
- There are options for innovative financing mechanisms for the public sector, which include green bonds and debt instruments as well as the use of revenue raising policies, like fees and charges.
- Public private partnerships offer strong opportunities, with the use of schemes such as Special Purpose Funding Vehicles and Build Operate Transfer schemes.
- The private sector is already investing in private GI assets and this is likely to increase, especially as incentives and regulations are introduced. The analysis in section 4.4 suggests that there are strong returns to the private sector from incorporating GI into property, which should ensure and expansion of private investment, funded directly by enterprises, either from profits or conventional borrowing.
- Development Finance Institutions are providing strong support in Cambodia, although this is currently focused on impact investment in the financial sector. There is scope to apply this to GI assets.
- There is very strong global interest in innovative private financing instruments, including bonds and impact investment by private investors. It is assumed that this will grow strongly.
- Finally, philanthropic sources will account for a small share of financing and can play a particular role, for example by funding innovative projects with high-risk returns.

Figure 16 Illustrative financing framework



5.5 Policies that directly support finance

The earlier sections of this chapter deal with the source of finance for GI investment and O&M. Most of the financing options are dependent to some degree on supporting policies. The rate at which new investment is undertaken will depend on the strength of the policies and the way in which they are enforced. This section focuses on specific policies that have a direct influence on spending decisions, rather than general policies that provide strategic orientation or wider plans.

Regulations and guidelines. Private and public investment in urban GI is strongly influenced by regulations and guidelines governing building standards and planning permission. In Cambodia, the

main source of regulations is Sub-Decree No. 43 on Urbanization of the Capital City, Towns and Urban Areas. Examples of areas where regulations may encourage or support GI include:

- building standards for climate change adaptation, including insulation, shading and cooling
- building standards for the quality of urban GI, especially of green roofs
- health and workplace comfort regulations, influencing investment in green cooling methods
- planning guidelines defining minimum GI quantity and functionality and/or tree cover in new developments
- ecological impact assessments and strategies that protect, restore and create habitats and species and increase biodiversity
- requirements of health impact assessments, relating to excess heat, noise and air pollution
- design standards for sustainable drainage, which consider retention, re-use, attenuation, infiltration and evapotranspiration of rainwater
- requirements for estimation and limitation of greenhouse gas emissions from new developments
- specification of targets for sequestration of carbon in new urban GI
- zoning in which different requirements are specified

Regulations aim to provide clear and specific requirements that can be easily monitored and enforced. Guidelines may be less strictly defined but may also be powerful if planning approval is dependent on following guidelines and if government uses the guidelines to negotiate favourable GI investment.

Studies and information. Governments normally take the lead in organising and funding studies to support policy definition and to provide information to potential investors. These can include:

- surveying and mapping of existing GI assets and proposals for new assets, especially in areas which are deficient or vulnerable
- research into urban GI typologies and techniques and the applicability of methods to local circumstances
- information portals that make national and international experience available to developers, operators and residents
- strategic studies to create frameworks within which the private sector can conduct high quality reliable feasibility studies that demonstrate benefits both to investors and to governments that are responsible for approving schemes
- participatory scenario planning studies to understand diverse visions of the future as well as trade-offs in different policy and practice interventions
- evaluation studies, to assess the challenges of GI initiatives and to highlight the successes
- studies of the implementation effectiveness of GI, the combination of green, blue and grey infrastructure systems, the type of vegetation that might increase retention, long-term maintenance, climate change impacts, co benefits and GI in informal settlements
- studies on riparian vegetation and river restoration projects, rice paddies and urban agriculture, in the form of community gardens or peri-urban individual plots

Public support for academic research and teaching can play an important role in building understanding about urban GI.

Promotion and awareness raising. The public sector has a role to play in raising awareness about GI, promoting good practice, and improving local stewardship and participation in co-designing of solutions including the following activities:

- promotional work to encourage the use of reliable methods of analysis and design

- promotional work to raise awareness amongst private investors
- campaigns to change local culture and shift public opinion so that residents and workers in the city demand stronger commitments to urban GI
- national education campaigns of GI to inspire examples of the long-term management of public green spaces, supported by bilateral and multilateral initiatives due to the clear synergies on interrelated development goals (Pasquini and Enquist, 2019; Thorn et al 2021)

Networking and convening. In addition to studies, information and awareness-raising activities, the public sector can play an important role in facilitating contacts between key stakeholders. These typically involve connections between developers and financial institutions (e.g., in the Innovative Finance Lab in Singapore).

Networking may also involve support for Civil Society Organisations (CSOs) which can encourage collaboration amongst initiatives such as urban living labs. There are usually good opportunities for philanthropic funding for such CSO networks and the role of the public sector may primarily be in providing official approval of the work, in addition to technical participation, quality control and validation. These initiatives can be influential in changing cultures, especially amongst the younger generation.

Capacity building. The private sector may engage in its own capacity building, with exchange of experience between private enterprises. CSOs can also be effective in building capacity (e.g., in Cambodia's Build4People initiative). However, the public sector is typically required to take the lead in formal capacity building, including in funding university education and training.

Security and surveillance measures are a crucial investment in both individual nodes and connections (Thorn et al., 2021). Actively involving the broader community in the management of urban parks may stimulate more social sanctions if vandalism or theft of public green space occurs, while solid waste management reduces ecosystem disservices (e.g., malodours, pollution, health hazards).

Procurement. Green procurement rules are commonly introduced to support wider green growth, including commitments to source only goods and services that have sustainability certification. This is not directly relevant to the promotion of the narrow definition of urban GI used in this study. However, some procurement rules may be useful for promoting successful urban GI, including requirements for purchase of plants that are locally produced, and suitable for local conditions.

6 Lessons from neighbouring countries

This chapter reviews how Cambodia, with a focus on Phnom Penh, compares to surrounding or neighbouring countries which have sustained urban GI and produced results. The analysis uses evaluations of the outcomes and lessons learnt for the implementation of urban GI in Southeast Asia, where these are available. The study has reviewed programme documents, reports, media pages, postgraduate dissertations and peer reviewed publications to determine outcomes, or expected results. We also draw from relevant international reviews.

6.1 Case studies of urban GI in Southeast Asia

6.1.1 Siam Green Sky, Thailand (launched in 2015)

Siam Green Sky[11] is the first and largest green roof of its kind in Thailand. It reclaims wasted concrete roof space for a productive landscape and introduces urban agriculture to the commercial heart of Bangkok.

Social benefits: The project educates visitors about waste and energy recycling through its own design: the farm recycles organic waste to become fertilizer for plants and solar cells are places at the edges of planting areas. Turning infrastructure into art, Landprocess invited Thai graffiti artists to paint murals around the site, providing cultural services such as social cohesion. **Environmental benefits**: The green roof has dedicated space to urban farming, evoking traditional rice terraces. The landscape is divided into sections—herb garden, vegetable garden, rice field.

6.1.2 Chao Phraya Sky Park, Thailand (launched in 2020)

Chao Phraya Sky Park[12] is a pedestrian bridge across the Chao Phraya River and the first sky park in Thailand. Completed in June 2020 by Bangkok's City Planning Department, the project regenerated the Lavalin Skytrain into a new public space.

Social benefits: A green pedestrian bridge to walk and exercise, cycle and socialize. **Environmental benefits:** The green pedestrian bridge connects the existing park on both sides of King Prajadhipok Park at the Phra Nakhon side of the river with the Chaloem Phrakiat Forest Park in Thon Buri. The Sky Park is the most recent initiative Sustainable Urbanisation for All Aside, a network of community organizations involved in urban and housing development, established in 2012 through collaboration between the Health Promotion Foundation and Chulalongkorn University. It coordinates knowledge and aid from various organisations related to urban development to restore and develop Bangkok's inner areas. Since its founding, it has worked with the Government, the private, education and civil society sectors in implementing several other urban regeneration projects, such as Yannawa Riverfront, Good Walk, Bangkok 250, Chulalongkorn

[11] www.asiagreenbuildings.com/9848/thailand-siam-green-sky-has-opened-their-largest-rooftop-garden/
[12] https://futuresoutheastasia.com/chao-phraya-sky-park/

University's 2nd Centennial Masterplan (CU2040), Chula Smart City, Active River Station, Bangkok Under-utilised Space and Urban Observatory and Engagement.

6.1.3 Chulalongkorn Centenary Park, Thailand

Chulalongkorn University Centenary Park[13] a (12-acre park with 1.3 km. green avenue) is the first critical piece of GI for the city of Bangkok, designed to mitigate detrimental ecological issues and add outdoor public space to the city.

Social benefits: Outdoor classroom and a roadway, promoting pedestrian and bicycle transportation. The road extends beyond the park in both directions and has linear rain gardens, with a multitude of native plants, along the road to absorb water and further extend the park into the neighbourhood. This road links major roadways directly to the park's walkways and water from neighbouring areas is treated by the park's filtration system. **Environmental benefits:** The Park has a green roof (planted with native grasses and weeds for low maintenance), a rainwater tank (runoff water is stored in rain tanks beneath the green roof and overflow drains to the constructed wetlands), it has a constructed wetland, a detention lawn and a retention pond. The rain and run-off water runs from the green roof at highest point to the retention pond at the lowest. Thus, the park helps to collect and treat water, decrease flood risks and reduce the urban heat island. Moreover, it continues an important "green corridor" from the main academic campus to a commercial area. **Economic benefits:** The Park links the city to the campus through this commercial zone incentivizing financial movements and increasing job opportunities.

6.1.4 Building with nature, Demak, Central Java, Indonesia (launched in 2015)

The five-year programme (2015-2020) focuses on the shoreline in Demak, Central Java, Indonesia[14]. The pilot programme seeks to use natural ecological processes to achieve efficient and sustainable hydraulic infrastructure, while integrating land in water and water in land using materials in nature and their interactions. The concepts, pilots, design guidelines and business cases are also being used in the Netherlands for the largescale coastal and river defences. Measures include mangrove restoration and the construction of permeable dams made of brushwood that capture sediment and help to establish a healthy sediment balance.

Social benefits: focuses on restoring the shoreline where sea level rise is projected to cause flooding 6km inland by 2100, inundating 14,700 hectares affecting over 70,000 people and the loss of 6,000 hectares of aquaculture ponds. **Environmental benefits:** Once the near shore bed level has sufficiently risen, mangroves will regenerate naturally developing a natural water defence protecting the hinterland against flooding and further erosion.

[13] https://landprocessdesign.wixsite.com/landprocess/cucentenarypark
[14] https://www.ecoshape.org/en/pilots/building-with-nature-indonesia/

6.1.5 ResilNam Project in Tam Giang lagoon and Hue City, Vietnam (launched in 2018 – ongoing)

Under the ResilNam Project[15], two types of ecosystem-based adaptation strategies are carried in the Thua Thien Hue Province, namely the restoration of urban water bodies of Hue City and the restoration of the mangrove at the Tam Giang Lagoon (Hagadoorn et al., 2018). These projects were jointly carried by Disaster Management Center, the Women's Union and local communities.

Social benefits: Reduced erosion from floods, increase tourism, fisheries and sustainable recreation. Furthermore, this project focused on empowering local women in disaster risk management. **Environmental benefits**: Including, planting mangroves in Tam Giang lagoon; restoring urban ponds in Hue City; and installing sluice gates between the river and the citadel. **Economic benefits**: High returns in investment over 30 y driven by substantial reductions in flood damages and an increase in tourism and fisheries (abundance of seafood in the lagoon). The total benefits are USD 641,000. USD 19,000 with the main components being the labour cost of cleaning, the ponds and the cost of waste disposal.

6.1.6 Eco-link @ BKE, Singapore (launched in 2013)

The Eco-Link@BKE[16] is a 62m-long wildlife link and ecological bridge that spans the Bukit Timah Expressway, connecting Bukit Timah Nature Reserve (163ha) and Central Catchment Nature Reserve (2,000ha). The main purpose is to restore the ecological connection between two nature reserves, allowing wildlife (e.g., Sunda pangolins, civets, native small mammals such as squirrels or shrub birds) to expand their habitat, genetic pool and survival chances. Partnerships with nature groups, NGOs, tertiary institutions, volunteers and government agencies was essential to conduct feasibility studies and ecological monitoring surveys.

Social benefits: Visitors can enjoy guided walks, as well as participate in educational and outreach activities to raise awareness on biodiversity conservation. Students carried out various reforestation planting projects. **Environmental benefits:** The forested habitat allows flying squirrels, monitor lizards, palm civets, pangolins, porcupines, birds, insects and snakes to move between the nature reserves and to find other food sources. Plants pollinate, propagate and disperse across the landscape (Chan and Davidson, 2019).

[15] https://www.weadapt.org/sites/weadapt.org/files/2017/september/resilnam_coastal.pdf
[16] https://news.mongabay.com/2017/07/how-effective-are-wildlife-corridors-like-singapores-eco-link/

6.1.7 *Jurong Lake Gardens, Singapore (First Park Lakeside Garden opened in 2019)*

Jurong Lake Gardens[17] is a 90ha space and the one of Singapore's newest gardens., while 200 ha land dedicated to greenery and a waterbody. It includes grasslands, a flooded island with a freshwater swamp forest, a boardwalk and a series of naturalised streams. **Social benefits:** Community and family recreation, cycling trails, a dog run, water playground where water movements that mimic tidal patterns, surface ripples and directional currents similar to those at coastal shores. **Environmental benefits:** The Park has Allotment Gardens and Floating Wetlands (the largest man-made floating wetland in Singapore). To maintain clean water a cleansing 48iotope is used which acts as a natural water treatment system. **Economic benefits:** Some private sector companies in related sectors have set up offices in the area (including CPG Corporation (infrastructure, building development & management services); Beca (engineering consultancy), Daimler (automotive) and Great Eastern Life (insurance)). The Park is envisioned to become a tourist destination. Together with the Jurong Lake Gardens and the New Science Centre, the Tourism Development will support JLD's position as a new 'must visit' leisure and recreational cluster. The Tourism Development will host retail, entertainment, hotels and open public spaces for day and night tours in the park and thus increase job opportunities in the district. When fully developed, it is estimated to provide more than 100,000 new jobs and 20,000 new homes.

6.1.8 *River of Life, Malaysia (launched in 2012)*

River of Life[18] is one of Malaysia government's Economic Transformation Programs, that aim to elevate the country to developed nation status. It was launched in 2012. The USD1.3-billion project covers the confluences of three city rivers, totalling 781 ha of land and 63 ha of water bodies. It aims bring the community 'back' to the river through transforming it into a vibrant waterfront with high economic and commercial value, rejuvenating and cleaning the city's river and re-connecting it to the surrounding urban fabric.

Social benefits: Beautification and psychological comfort. Community education, creating awareness (e.g., campaigns, talks, exhibitions), expanding knowledge (social media, books and newsletters), upgrading skills (demonstration, training and workshops) and pollution prevention, monitoring and river audits). Strategic framework for urban and landscape design guidelines constructed on a baseline. **Environmental benefits:** River cleaning was conducted along a 110 km stretch along the Klang River basin, covering the municipal areas of Majlis Perbandaran Selayang, Majlis Perbandaran Ampang Jaya and Dewan Bandaraya Kuala Lumpur. **Economic benefits:** Master planning and beautification spurred economic investments ainto the areas immediately surrounding the Klang and Gombak rivers corridor. Government land was identified and tendered out to private developers to deliver affordable housing for more than 35,000 new residents, 1 million m^2 of commercial space, more than 27,000 new employment opportunities, raising the public transportation from 15 – 60% and reducing traffic demand by 15 % (Schneider, 2018; Zuraimi et al., 2020).

[17] https://www.jld.gov.sg/

[18] https://aecom.com/projects/river-life-klang-river-malaysia/

Box 6 Baseline and adaptation assessments

Baseline and adaptation assessments are key to determining the status and condition of a system and its components. This can involve mapping key elements of GI – and their current quality, ecological and social status, ecosystem services, levels of pollution and different land uses, amongst other considerations. It is important to understand what the infrastructure was intended to do to assess it is functioning effectively. Hot spot mapping is a rapid method of undertaking an initial threat or flood hazard assessment of the entire town with climate change – for instance in terms of frequency, depth and duration. This can be tested under different scenarios. The intention is to identify those areas which require priority attention either by special land use zoning and/or by defining special safeguards to guide and control development in the hot spots. For example in Kaysone Phomvihane City Center, Lao this method was used to establish zone development controls which then enforced strict stormwater management controls and monitorable tree canopy cover targets), se green space targets and guidelines (20% by 2020), protect green spaces against developments, increase GI where there was shortages, provide small grants to local community groups to improve the existing spaces and amending the master plan to ensure community health and wellbeing is central consideration in developments (AFB, 2015). Adaptation and vulnerability assessments involve assessing the past extreme events and impacts on the systems, determining vulnerability and adaptation and mitigation strategies and to co benefits and trade-offs of GI options. For instance, in Savanxay Market, Kaysone Phomvihane, Lao, a vulnerability assessment involved considering the threat, exposure, severity, impact level, impact summary, vulnerability and adaptive capacity. Installing the natural drainage capacity and using bio-engineering along the canal and around the market and its vicinity facilitated the drainage of storm water to the avoid Mekong River flooding.

6.1.9 Kampung Admiralty, Singapore (completed in 2017)

Kampung Admiralty[19] is a therapeutic garden for a 11 storey retirement village – which was converted a building into a layered green wall. **Social benefits**: Programmes use plants and plant-related activities to improve the physical, mental and social well-being of individuals.). **Environmental benefits:** Engineered wetland cells that offer effective treatment of river and pond water. Residents and students planted a variety of butterfly-attracting plants to create butterfly habitat. An allotment garden involves 70 gardening plots. Mangrove restoration projects showcase the transformation of concretised canals into naturalised waterways. By using these techniques, a 2,700 m long, 17-24 m wide, straight concrete drainage channel has been restored into a 3,200 m long, 100 m wide, natural river meandering through the park (An et al. 2020) – supporting aquatics species movements, reducing runoff and improving water quality (Hwang and Jain, 2021).

[19] https://tnp.straitstimes.com/news/singapore/kampung-admiralty-wins-worlds-top-architectural-award

6.1.10 Bishan Ang Mo Kio park and Kallang River, Singapore (upgrade completed in 2012)

Bishan Ang Mo Kio park[20] is one of Singapore's most popular parks. A 2.7 km long straight concrete drainage channel was restored into a 3.2 km natural river, that meanders through the park. 62 ha of the park accommodates the river system. The landscape is designed as layers of green and blue infrastructure that connects residents and the greater Admiralty neighbourhood to the historical "Kampung" village. The eco-pond promotes biodiversity and a natural urban cooling effect. The Project is part of the Active, Beautiful, Clean Waters (ABC Waters) Programme, a long-term initiative to transform the country's water bodies beyond their functions of drainage and water supply, into vibrant, new spaces for community bonding and recreation.

Social benefits: An elevated green village where residents can exercise, socialize and manage community farms. It comprises of a Community Plaza in the lower stratum, a Medical Centre in the mid stratum and a Community Park with apartments for seniors in the upper stratum. Multifunctional building uses (healthcare, social and commercial) support inter-generational bonding and promote active ageing in place. The Community Plaza is a fully public, porous and pedestrianised ground plane, designed as a community living room. Within this space, the public can participate in organised events, join in the season's festivities, shop, or eat. The bioretention basin located at the medical centre provides a therapeutic environment for patients while also functioning as a system to harvest, cleanse and recycle rainwater. **Environmental benefits:** The vertical village includes a tropical rainforest, ground level planting, green roofs and vertical green walls as well as the development of a hydrological system, where more than a million gallons of tap water is conserved each year as stormwater runoff is stored in the rainwater harvesting tank and reused for irrigation.

Box 7 Stakeholder engagement

Developing a community engagement plan is a key element of any GI implementation process. Different community sectors will have different roles and responsibilities in terms of planning, financing, policy formulation, approvals, implementation, management, monitoring and maintenance. Types of stakeholders who are typically engages in GI projects include for instance district, provincial and central government sectors, NGOs, banks, disaster risk reduction divisions, CBOs, international organisations, property owners, women and youth groups, public works, shops, commercial developments, educational institutions, food establishments, hawkers, wet markets, workshops, industries, corporations, educational institutions, food establishments, hawkers, wet markets, workshops, industries, corporations and developers and transportation agencies. As a priority, local community members that are directly affected by the GI measures, as well as those vulnerable to the impacts of climate change should be engaged and consulted at the outset as their participation and buy-in (ADB, 2015). Regular consultations and meetings with key decision makers helps to address concerns. For example, in the River for Life programme in Malaysia, public outreach programmes involving on-the-ground education and behavioural change towards caring for rivers of target groups such as public, to reduce pollution (Department of Irrigation and Drainage Malaysia, 2018).

[20] https://c40-production-images.s3.amazonaws.com/other_uploads/images/1963_AD-Ref_Singapore_Bishan-Park.original.pdf?1538133801

6.2 Coordinating strategies

Urban GI plans and policies. Phnom Penh is unusual in Southeast Asia in having a Green City Strategic Plan that focuses specifically on urban GI, including trees and green roofs. Other cities in the region have a variety of related policies, including policies that relate specifically to some aspects of urban GI, such as drainage and stormwater (see Table 12).

Table 12 Selected cities in Southeast Asia that have policies and plans on GI

City, Country	Street trees	Green roofs	Sustainable drainage
Phnom Penh, Cambodia[21]	Cambodia Seed Tree Project; Cambodia's National Forest Policy Statement and Guidelines	Phnom Penh Sustainable City Plan 2018-2030	Phnom Penh Green City Strategic Plan 2017-2026
Singapore, Singapore[22]	Park and Trees Act	No	Yes
Kuala Lumpur, Malaysia[23]	National Landscape Policy, National Urbanisation Policy, Environmental Policy, Landscape Planning Guidelines	No	Undetermined – Urban Stormwater Management Manual
Bangkok, Thailand[24]	Urban Community Park Programme	No	Undetermined – flood prevention policy
Hanoi, Vietnam[25]	Law on Cultural Heritage, Renovation and Development of the Old Quarter of Hanoi	Undetermined	Hanoi City Drainage Master Plan

Wider green strategies, plans and policies. Many countries, including Cambodia, have developed green growth strategies that coordinate wider green growth, including actions that deliver benefits associated with climate change and the environment across all sectors of the economy. It is less common to have a national strategy specifically for urban GI, as defined narrowly in this study. Cambodia has the Green Urban Development Programme, implemented with support from GGGI, and the Phnom Penh Sustainable City Plan 2018-2030. These adopted a relatively broad definition of GI, including: urban planning and vulnerability; energy; transport; the built environment; manufacturing; waste and public space (GGGI, 2018). The Plan includes recommendations that relate to the narrow definition of urban GI including: zoning land use; defining protected areas; green building standards; enforcement of planning regulations; and expansion of green space. The Plan also includes recommendations for improved public participation in urban planning, which would help to ensure that the public benefits gained from GI were considered in urban planning.

Box 8 Examples of strategic policy approaches

Cambodia, Laos and Vietnam's Zone. The zone provides safeguards and development guidelines for towns along the Mekong (ADB, 2015).

- Conserving historic sites by registering heritage areas and trees, banning felling of historic trees, increasing permeable surfaces, developing rehabilitating standards, expanding green space and networks of walkways, developing ecotourism sites with local heritage committee and participation.
- Reserving peri-urban areas for public green space and natural drainage corridors, protecting forests and green spaces and ensuring all development and infrastructure in the zone to apply GI approaches.

[21] www.fao.org/3/ac648e/ac648e04.htm, https://gggi.org/site/assets/uploads/2019/06/SUBSTAINABLE-CITY-REPORT_EN_FA3.pdf, https://ncsd.moe.gov.kh/sites/default/files/2019-05/Phnom%20Penh%20Green%20Strategic%20Plan.pdf

[22] https://sso.agc.gov.sg/Act/PTA2005, https://www.irbnet.de/daten/iconda/CIB_DC26360.pdf

[23] https://www.matec-conferences.org/articles/matecconf/abs/2018/105/matecconf_iswso2018_01112/matecconf_iswso2018_01112.html, https://aip.scitation.org/doi/pdf/10.1063/1.5055460

[24] www.sciencedirect.com/science/article/pii/S0959652618317104, https://ph02.tci-thaijo.org/index.php/sej/article/view/135932/158787, https://www.tandfonline.com/doi/abs/10.1080/10549811.2016.1265455?journalCode=wjsf20

[25] www.researchgate.net/publication/335590467_Cost_assessment_of_Green_roofs_-_Case_study_in_Hanoi https://icem.com.au/study-on-hanoi-water-pollution-and-drainage-management-approaching-closure/uncategorized/

- Ensuring all new roads and transport facilities maintain natural drainage patterns and follow GI methods, demarcating, rehabilitating and protecting natural drainage corridors and creating GI drainage systems and bioswales along streets.
- For urban agriculture, developing agreements with farmers to allow agricultural land to be managed as flood retention in areas of extreme events and re-introducing agroforestry.
- In industrial areas, setting strict green space to building ratios for industrial zones and each building/plant site, requiring rainwater capture and management on site, raingardens, bioswales and ensuring that parking, roads and drainage include GI safeguard designs.
- In commercial areas, creating green walkways and bicycle paths along streets, applying building design standards which accommodate flood conditions such as elevation, orientation and drainage and establishing monitoring and management committees involving enterprises for greening and maintenance of their shared areas.
- In the inner city, enforcing strict building design standards to maintain old town character and to promoting effective water management.

Malaysia's Sustainable Finance Policy. GI investment opportunities report series highlights innovative approaches. Malaysia has shown global leadership on sustainable finance, implementing a range of policy instruments (Climate Bonds Initiative 2021) such as:

- 2009 National Green Technology Policy which emphasizes the central role of green technology in Malaysia's green development, overseeing greening in four sectors, including energy, buildings, water and waste management and transport.
- 2009 Green Building Index which helps to enable green grading and certification of Malaysian buildings.
- 2010 Green Technology Financing Scheme to create a policy environment that would attract innovators and users of green technology.
- 2011 Low Carbon Cities Framework that addresses carbon emissions in 4 main areas: urban environment, urban infrastructure, urban transportation and buildings.
- 2013, 2019 Minimum Energy Performance Standards that specify the minimum level of energy performance that appliances, lighting and electrical equipment (products) must meet or exceed before they can be offered for sale or used for commercial purposes.
- 2019-2030 National Transport Policy that aims to reduce the negative effect of the transport industry on the environment.

Thailand's Biodiversity Financial Plan. One of Thailand's long-term policy priorities is the development of urban green spaces, including recreation areas and natural paths that help raise environmental awareness and enhance the quality of urban life. A National Adaptation Plan, a Memorandum of Understanding (MoU), the fifth phase of its Biodiversity Financial Plan (BFP) (2018-2022) were recently developed and signed to enhance climate change adaptation and to address financial priorities for biodiversity conservation. It sets out an integrated national approach which builds the economic and business imperative for scaling biodiversity protection. The Biodiversity Financial Plan was prepared in line with the Biodiversity Policy and Institutional Review, the Biodiversity Expenditure Review and the Financial Needs Assessment in response to the National Biodiversity Strategy and Action Plan. See https://www.biofin.org/knowledge-product/biodiversity-finance-plan-thailand). These efforts required inter-governmental cooperation with the Office of National Water Resources, the Department of Health Department of Public Works and Town and Country Planning and the Department of Tourism. Among a list of priorities are wildlife and green space conservation with the support of financial tools for the management of biodiversity pilot areas.

Singapore's Green Plan 2030. The Singapore Green Plan 2030 is a national development plan to advance Singapore's sustainability agenda and help achieve Sustainable Development Goals and Paris Agreement, while positioning the city to achieve net zero emissions as soon as is viable. Singapore is a low-lying state particularly vulnerable to climate change. The city is one of the greenest cities in the world. This plan aims to transform the city in the next ten years. This includes setting aside 50% more land, or 200 ha, for nature parks; every household living within 10 minutes' walk from a park and planting 1 million more trees across the island – projected to sequester 78,000 tonnes of CO2 and provide cleaner air and more shade. Other elements of the plan include adding 130 ha of new parks, enhancing existing parks by 170 ha; setting aside 1,000 more ha for green spaces by 2035, while working with communities and NGOs to develop programmes to allow people and wildlife to live in harmony. https://www.greenplan.gov.sg/key-focus-areas/overview#city-in-nature

6.3 Overcoming challenges for green infrastructure in Southeast Asia

Across many Southeast Asian countries, there remain key barriers to mainstreaming GI. Projections of rapid urban growth and important risks of flooding and water pollution make integrated urban water management using GI critical. Yet, the body of literature in Southeast Asia is still small and dominated by wealthier countries while there remain knowledge gaps on the performance of GI. For the purpose of this report, we focus on two key barriers which have practical relevance for the design, performance and maintenance barriers of GI in Phnom Penh.

Design standards and knowledge barriers. Technological barriers relate to the deficiency of data about performance characteristics and insufficient technical knowledge and experience of GI. Hamel and Tan (2021) lay out four key environmental characteristics of SE Asian countries distinguish from many other regions and need to be carefully considered when designing GI.

1. First, the tropical monsoon climate is hot and humid, with frequent intense events - with implications for water storage management. For example, the intensity of a 1-h storm occurring every 2 years in Singapore is equivalent to a storm occurring every 100 years in New York (Public Utilities Board Singapore 2013).
2. Second, most SE Asian trees are evergreen, with only a few deciduous species found in the dry forests (e.g., in Myanmar), resulting in little seasonal variation in ecological functions other than due to climate.
3. Third, soils generally have high clay contents and medium to low permeability (e.g.,., Acrisol–Alisol types, Chappell et al. 2007). This means the soil may be less effective at retaining water but still provide high drainage rates – making then important for water security.
4. Fourth, there is a high presence of large deltas such as the Mekong, the Irrawaddy, and the Chao Phraya deltas, which all comprise large wetland areas. The flat topography exposes urban and rural settlements to frequent flooding (e.g., Siripong et al., 2000).

Two socioeconomic characteristics are critical to consider when designing GI.

1. Subsidence due to groundwater pumping exacerbates flooding issues, but GI that increases infiltration may mitigate this issue, while also replenishing groundwater resources for consumption.
2. Cities in SE Asia are often characterised by high levels of informality. More than 370m people live in informal settlements in SE and Eastern Asian cities, making up to 50% of the urban population in some countries (Hamel and Tan, 2021). Uncontrolled growth often exacerbates water management issues, makes population vulnerable to hydrometeorological hazards, with limited waste collection and sanitation services also severely impacting water quality.

In addition, governance characteristics are also critical to consider.

1. Weak governance systems means that many official plans and regulations are not implemented – with market forces driving infrastructure change and resulting in urban sprawl and which acts as a barrier to integrated water management (Yap, 2018).
2. Second, apart from Singapore and Malaysia, generally Southeast Asian countries have a low sewerage cover – averaging 17.3% of urban dwellers being connected to a sanitation sewer network (World Health Organisation and UNICEF 2017). Most cities include open canals that drain both stormwater and wastewater. Water often drains into the nearest river – making water purification an essential service to remove pollution. The poor status of wastewater management means that the reduction in runoff caused by GI becomes much more important in Southeast Asian cities that don't have good sewerage coverage.

One approach to overcome challenges is to develop design guidelines for GI. A review by Hamel and Tan (2021) of 109 studies on Gi in Southeast Asia, suggests that design should consider the following factors, amongst other, for the successful planning, design, implementation, operation, maintenance, and evaluation of urban GI. The list is not exhaustive, and further research is needed, but the review suggested some key design guidelines relevant for the Southeast Asian context.

- Local climate conditions need to be taken into account, including the need to consider runoff volume instead of the more traditional average recurrence rainfall intervals (e.g., 3-month return), since the latter does not adequately capture the wide range in rainfall intensity in the tropics (e.g., Yau et al., 2017).
- Different engineering solutions need to be considered, such as how different approaches to bioretention ponds reduce peak flow (e.g., Wang et al., 2017).
- The effect of deforestation at the landscape or catchment scale, soil and vegetation type, including upstream forested areas to reduce downstream flooding in urban centres (e.g., Abdulkareem et al. 2018 study in Malaysia).
- Irrigation for urban and peri urban areas needs to be considered. For instance, plant species may require manual irrigation, contrasting with water quality guidelines on plant selection (e.g., Ong et al., 2012) and climate change scenarios (e.g., Fletcher et al., 2013)

Other examples of design guidelines are Singapore's Active Beautiful Clean (ABC) Waters programme and the Asian Development Bank GI guidelines.

Performance and maintenance. Long-term maintenance and performance are other key challenges. Stormwater management best practices that focus on mimicking the pre-development water cycle—reducing runoff volumes and increasing infiltration—have been shown to improve ecological impacts. Calculating water budgets at the catchment scale is a more effective approach than at the site scale. Compared to other countries in Southeast Asia, the Philippines and Singapore are considered to have higher levels of integrated water management compared to other countries in the region (UNEP-DHI Centre on Water and Environment 2020).

While GI in certain instances are not sufficient to address larger scale hazards, hybridised infrastructure is a solution. Although there exists limited understanding of the optimal combination of GI and grey infrastructure, in Thailand concrete canals and retention ponds have been combined (Ditthabumrung and Weesakul 2019). In Vietnam, Nguyen et al. (2019) found that expanding pipes was more effective at reducing stormwater volumes than implementing green roofs. Combining GI and grey infrastructure appears to be more common in wastewater treatment systems. For example, domestic wastewater in Can Tho and Ho Chi Minh, Vietnam is passed through a septic tank before being treated in wetland systems (Tran et al. 2019).

7 Conclusions and recommendations

This final chapter of the report draws together the main conclusions from the previous chapters of the report and makes recommendations for a three-phase programme for implementing the scenario described in sections 4.5, 5.4 and 5.5.

7.1 Conclusions

Existing GI assets in Phnom Penh. The study conducted an aerial assessment of GI assets in Phnom Penh, providing the baseline for future expansion of GI. The assessment mapped the Normalised Difference in Vegetation Index, as presented in chapter 2, which shows there is a wide variation in the vegetation index. Chapter 2 also presents the results of research that suggests that Phnom Penh has amongst the lowest levels of GI in Southeast Asia, although there are challenges in presenting this analysis in a consistent manner, given differences in settlement patterns amongst cities. These results provide a starting point from which to make decisions about possible zoning of the city.

Current views on GI in Phnom Penh. This study undertook a consultation on current views about GI using semi-structured interviews. The consultation covered: 8 key informants (including officials from relevant ministries and the Phnom Penh municipality, research institutes, development partners and private developers); and a panel of 15 public representatives (e.g., businesses, local residents, tour operators, real estate agents, police officers, construction businesses, health workers, drivers, professors, cleaners and urban designers).

The interviews revealed a strong awareness and interest of urban GI and especially of trees and gardens. There was also significant awareness of green roofs and green walls, rivers, rainwater harvesting, although verges were considered less important.

The survey suggests that roughly half of the risks identified by urban residents are reduced using GI and all 12 of the risks related to flooding are reduced. Key stakeholders felt that the biggest challenges to the expansion in use of GI were related to a growing population, demand for land and development, public support in the form of financing, monitoring, technical capacity and highlighted the need for clearer regulations and guidelines and improved incentives.

The consultation showed a wide level of awareness in the benefits from GI amongst residents, with particular interest in reduced pollution, cooling, living environments (both indoor and outdoor) and mental health. Benefits associated with water quality, carbon emissions, energy efficiency, physical activity and noise were also recognised, but were considered a lower priority. The key stakeholders were aware of the full range of benefits and reported strong interest in all the benefits.

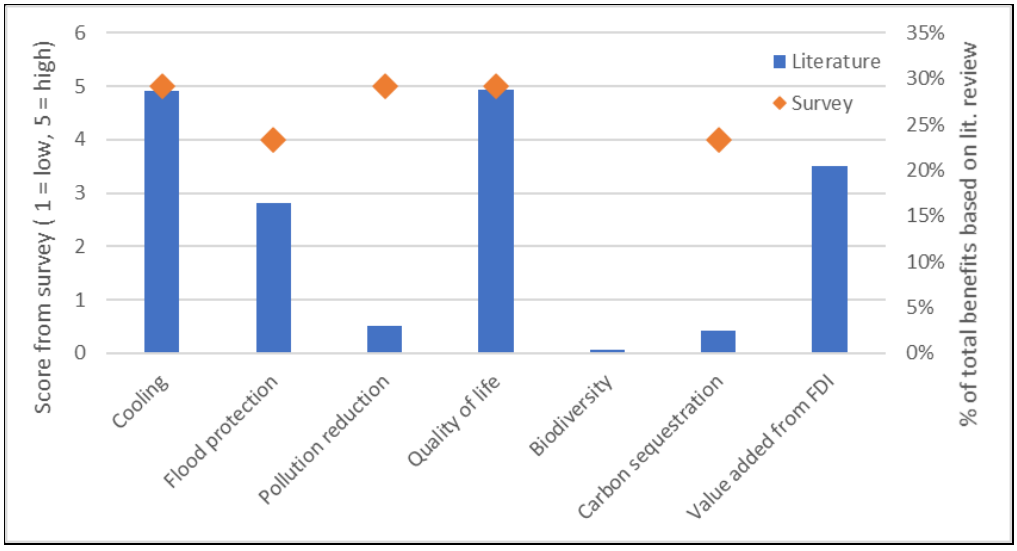
Cost benefit analysis. The study reviewed about 40 papers with evidence about the costs and benefits of urban GI, including several that were themselves reviews of many case studies. This review showed that there were wide variations in the way in which the costs and benefits of GI were reported, which make it difficult to compare the results and consider their relevance to Cambodia. Nevertheless, the report proposes 'typical values' for the unit costs and unit benefits of each type of GI asset (see Table 9 and Figure 8). The analysis showed that different assets contribute to different ranges of benefits and that all the benefits are important, with particularly strong benefits related to cooling, flood reduction and quality of life.

The values should not be considered as accurate estimates of the costs and benefits and decisions about GI investments require research to assess the values that apply in the location. They are, however, reasonable mid-range estimates that can be used to assess total potential costs and benefits

of a programme of GI investment. There are also suitable as 'yardsticks' that may guide the collection of site-specific information and act as comparators for a national library of evidence and experience.

Consistency of survey results with international literature review. Figure 17 summarises the evidence from the survey and the literature review to explore the consistency of the evidence. Seven types of benefit are identified. For the survey, the evidence is taken from Table 3. For most of the seven broad types of benefit, the table includes several related questions and Figure 17 uses the highest of these related questions for each of the seven types of benefit. For the literature review, the figure reports the proportion of the total benefits that is expected to be derived if the scenario described in section 4.5 is implemented. Figure 17 shows that the survey results are consistent with the international literature in reporting very high value for cooling and quality of life benefits. The two sources of evidence are also consistent in reporting that flood protection benefits are important, although to a slightly lesser degree. There is, however, some inconsistency in the evidence for the importance of pollution reduction and carbon sequestration, with the survey reporting views that suggest these benefits are much higher for Phnom Penh residents than is suggested by the international literature. For pollution reduction benefits, this may reflect the high levels of pollution in central Phnom Penh, relative to many of the cities covered in the literature review. For the benefits of carbon sequestration, the higher value registered in the survey may reflect the fact that the importance of climate change has risen greatly in the last few years, since most of the international studies were undertaken, and that the survey was undertaken very shortly after the UNFCCC Conference of the Parties meeting in Glasgow. The international literature reported strong benefits from value added arising from inward investment, which was not covered in the survey. Biodiversity benefits were considered small in the literature and were not covered in the survey.

Figure 17 Relative importance of benefits: evidence from the survey and literature review



A scenario of GI expansion in Phnom Penh. Section 4.5 uses the evidence from the international literature to describe a 'moderate scenario' of GI expansion in Phnom Penh covering 10 years with equal annual commitments to investment and a growing requirement for operation and maintenance (O&M). The total annual costs by year 10 are about USD 50m and the increase in GI assets covers about 2400 ha, which is about 3.5% of the total administrative area. The scenario includes a mixture of high value investment in green roofs and green walls, which may be required in more central districts, as well as trees, parks and gardens which may be appropriate across the whole city.

An assessment is made of the likely distribution of benefits between the government, private enterprises and residents and workers of the city. Fiscal revenue comes from taxes on higher property values and higher incomes and profits. Figure 13 shows that public revenue will increase slightly more

than the additional O&M required for public GI assets. For the private sector, increased profits are nearly double the costs of O&M. Most of the benefits are experienced by residents and workers in the city.

The analysis of the moderate scenario includes assumptions about the sources of financing, with the private sector covering most of the green walls and green roofs, as well as private gardens and the public sector funding most of the trees, public parks and verges.

If the moderate scenario were expanded by 50%, it would put Phnom Penh amongst the cities in Southeast Asia with the best urban GI. A less ambitious scenario is also possible but would be wasteful because a substantial investment in policies and investment proportion is required and, if this is successful, should be able to deliver the levels of funding required for the moderate scenario.

Financing and policy framework. The report presents a preliminary financing and framework for the moderate scenario, with 9 potential sources of finance, illustrated in Figure 18. The framework reviews seven potential financing mechanisms that can be used to help develop GI. It should be possible to obtain grants to cover the policy development. Both the public and private sector will need to continue to be involved, but they both have good opportunities for accessing innovative source of finance. The report also reviews supporting policies that are either required for successful financing or that influence the scale of financing. Figure 18 summarises the relative importance of each policy for different sources of finance.

Figure 18 Relative importance of policies for financing sources

	Financing sources							
	Public			Private				Public Private Partnership
Policies	Budget	MDBs	Inno-vative	Enter-prises	DFIs	Inno-vative	Philan-thropy	
Regulations and Guidelines	Low	Mid	High	High	High	Mid	Mid	High
Studies and Information	Mid	High	High	Mid	High	High	Mid	High
Promotion and Awareness	Low	Mid	Low	Mid	Mid	Mid	Mid	Mid
Networking and Convening	None	Mid	High	Mid	Mid	High	Low	High
Capacity Building	High	Mid	High	Mid	Mid	High	Mid	Mid
Procurement	Low	None	None	None	None	None	None	None

7.2 Recommendations

Regardless of the scale of ambition for the expansion of GI in Phnom Penh, there is likely to be a common sequence of initiatives with phases for design, piloting and implementation.

Phase 1 – Policy Design and Capacity Building. The first priority for scaling up GI is to develop policies, to build capacity to access new sources of finance and to prepare a GI Masterplan that can bring together financing sources, especially during the early years when grants and concessional finance should be available.

- The development of supportive policies will cover: planning and building regulations; tax incentives; regulations on user charges and income generating activities; and associated guidelines and institutional roles for public, private and civil society.
- Building capacity to access new finance will involve the specification of institutional responsibilities, which is likely to include a promotional unit with participation from MEF, the Municipality and the financial sector. It will establish connections with national and international funding institutions, such as the Innovative Finance Lab and the green bond units in major international financial institutions. It will also connect with the Cambodian institutions involved in impact investing and explore with them the potential for transferring to GI the strong expertise they have in the financial sector. A detailed feasibility study on the nature of potential PPP for urban GI could be included.
- Preparation of a GI Masterplan for Phnom Penh, with clear zoning and targets for the area of GI assets in each zone of the city and indicative sources of funding, building on the outline provided in the financing framework presented in section 5.4. This is a substantial task, involving significant research and consultation.
- The Masterplan should include a baseline survey and mapping of current assets, along with mapping of vulnerabilities associated with flooding, the urban heat island effect and other climate change impacts, air pollution, noise pollution, ecological sites and networks, social and cultural assets and reviews of the functionality of different forms of GI asset. Some stakeholder consultation should be included in the survey.
- The Masterplan should also specify the system for monitoring changes in GI assets, possibly including a tree and other vegetation survey and undertaken through a combination of aerial or satellite imagery and ground truthing, which accounts for multiple benefits (e.g., well-being, cooling, flood, biodiversity and carbon). This may include a system such as the Urban Neighbourhood Green Index, as recommended by Build4People[26], opportunity mapping[27] or the latest computer modelling[28] or a combination with different functions in different districts. These activities should incorporate public participation, where possible.

This phase will take at least two years and involve setting up units in MEF and the Municipality, supported by national and international technical expertise. These units may be temporary task forces, with the expectation that they will become permanent features in MEF and the Municipality when implementation of the GI Plan starts. It will require public consultation on proposed reforms. A budget of at least USD 0.5m to USD 1m will be required. This should be available as a grant from bilateral partners of technical assistance channels in Multilateral Development Banks (MDBs).

Box 9 GI assessment tools

Table 13 review the strengths of 11 tools for prioritising GI investments. 'Range' refers to the extent to which the tool is applicable across the full range of GI assets likely to be important in Phnom Penh. 'Learnability' refers to the skills and training required to operate the tool. 'Practicality' refers to the level of evidence required to operate the tool. 'Economic focus' refers to the extent to which evidence is provided on the economic value of benefits

Table 13 Relevance of tools for GI valuation in Cambodia

Tools for GI valuation	Scope	Learn-ability	Practicality	Economic focus
Urban Greening Factor (UGF)	●	●●●	●●●	●
Nature Value Explorer (NVT)	●●●	●	●●	●●
i-Tree	●	●●●	●●	●●●

[26] https://build4people.org/wp4-urban-green/
[27] see https://www.london.gov.uk/sites/default/files/bestpracticeguide_a4-10.pdf
[28] https://www.envi-met.com/

GI Valuation Toolkit (GI-Val)	●●●	●●	●●	●●
Guide to Value GI	●●	●●	●●●	●●
TESSA	●●	●●	●●	●●
InVEST	●	●●	●●	●
EcoPlan Scenario Evaluator	●	●●	●●	●
GI Benefits Valuation Tool	●●●	●●●	●●●	●●●
CAVAT	●	●●	●●	●●●
Benefits Estimation Tool (BeST)	●●●	●●	●●	●●●

We suggest that, in Cambodia, it may be useful to think of several different tools, for different purposes and that there could be some value in continuing to work with the same tool, to establish consistency.

1. Urban Planning – Urban Greening Factor (UGF)[29]. The UGF is a well-tested practical planning tool that can be efficient in deciding whether to support individual GI investments. Monetary valuation is not attempted, which makes the tool simpler and more practical to use.
2. Appraisal – CIRIA SUDS BeST Tool[30]. Once planning has been granted in principle, the appraisal of individual investment proposals needs to include some assessment of the costs and economic benefits of alternative approaches to the investment. The BeST tool is a reliable and practical tool for this.
3. Strategic Targets – IUCN 3:30:300 Targets[31]. The IUCN have developed an international approach which suggests that cities around the world can aim to invest in GI so that: a) every city resident can see 3 trees from their house; b) there is 30% tree canopy across the city; and that every resident is within 300 metres of a park.
4. Urban Neighbourhood Green Index. The UNGI was selected by the Build4People[32] project in Cambodia, after an extensive literature review and is particularly useful for promoting structure community consultation.

Independent and academic research will normally focus on a particular facet of GI policy and will select the best tool to address that specific focus.

Phase 2 – Piloting. Once the policies are in place, a piloting phase will apply the policies and financing mechanisms in a few selected zones in Phnom Penh. The pilot phase will have targets for the area of GI to be created and the range of assets that will be funded. Some piloting of new planning and building regulations will be attempted, although conformity with regulations may need to be voluntary if the regulations are not being applied across the whole city. At least some of the following policies and financing mechanisms will be piloted.

- Introduction of incentives related to tax or interest rates.
- A Special Purpose Funding Vehicle (SPV), with the objective of bringing together finance from a range of different sources.
- A PPP contract for the design, build and operation of a GI asset.
- Green bonds for public investment and for private investment, with diversified investors, including local investors, private financial institutions, private impact investing and MDBs.

The piloting phase could include some adaptive research on the most appropriate forms of GI for Phnom Penh, to reflect the climatic conditions, building practices and social and cultural traditions.

[29] https://www.london.gov.uk/sites/default/files/urban_greening_factor_lpg_pre-consultation_draft.pdf
[30] www.susdrain.org/resources/best.html
[31] https://iucnurbanalliance.org/promoting-health-and-wellbeing-through-urban-forests-introducing-the-3-30-300-rule/
[32] https://build4people.org/wp4-urban-green/

This would include experimentation with difference species and techniques for GI assets. It could also include social and cultural research using, for example, of an urban living lab[33].

This phase will take two to four years, depending on how effective the regulations and capacity building have been. The target levels of finance raised would be agreed in the design phase, but targets are likely to be USD 1m to 5m per year by the end of the piloting phase.

Phase 3 – Implementation of the GI Master Plan. The third phase will start with a revision of the GI Masterplan, to take account of lessons learnt during the piloting phase. New regulations will be passed as soon as possible to make all new policies and regulations mandatory across Phnom Penh. New investments will aim to follow the revised GI Plan for the city. This phase will be reviewed after 5 years to establish how best to continue with the expansion of GI in Phnom Penh. Based on the moderate and ambitious scenarios outlined in this report, funding for the implementation plan will reach USD 50m to 80m a year, when the plan is being fully implemented.

Institutional Responsibilities. MEF should lead on all matters of fiscal policy, although reforms to taxes will need to involves some consultation. Public expenditure will require collaboration and negotiation between MEF and Phnom Penh Municipality. Changes to regulations and guidelines will involve MLMUPC but will need careful collaboration and consultation with private enterprise. Initiatives to expand innovative funding sources will also require collaboration, both nationally and internationally. There may be a role for a coordinating forum or council to bring all stakeholders together. International sources of finance can be invited to participate, given the important role they can play in facilitating exchange of international experience and networking with international sources of finance.

[33] https://unalab.eu/en/urban-living-labs

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Annexes

7.3 Annex 1 Summary findings report on the public panel survey

1. Establishing the value and demand for existing green assets

1.1. What do you understand by the term "green infrastructure"?

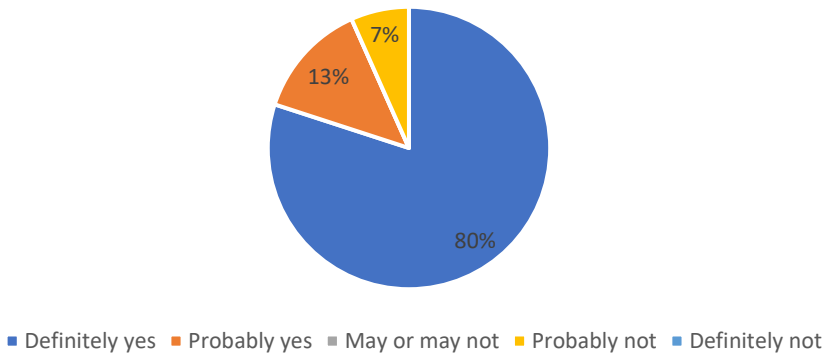
GI relates to the development of a green environment – aiding the well-being, the comfort and sustainability of the residents and making life beautiful. This can include: a path accompanied by green garden trees, street trees and plants, public road services, public parks, roads, gardens, or pagoda with garden. GI is developed in conjunction with a wide range of roads, including water supplies, sewerage, electricity, housing, buildings – all in accordance with the regulations of the government, schools and hospitals.

1.2. Please describe which of the following main types and sub-types in Phnom Penh represent existing GI initiatives or what is needed

Urban green infrastructure type	Ranking of importance
Trees (conventional street trees)	100.00 %
Gardens (public parks, sports facilities)	100.00 %
Trees (blue street trees)	85.71 %
Gardens (private home gardens)	85.71 %
Gardens (rain gardens)	57.14 %
Green roofs (extensive)	42.86 %
Gardens (ponds)	35.71 %
Green walls (extensive)	28.57 %
Green walls (intensive)	28.57 %
Verges (highways, roads and sidewalks)	28.57 %
Lakes	28.57 %
Green roofs (intensive)	21.43 %
Verges (channelized verges and streams)	21.43 %
Springs and fountains	21.43 %
Trees (afforestation Miyawaki)	14.29 %
Wetlands and floodplains	14.29 %
Rivers and streams	14.29 %
Verges (swale)	7.14 %

1.3. Have these urban GI types in general changed in the last ten years?

Figure A1. Changes in GI in the last 10 years in Phnom Penh



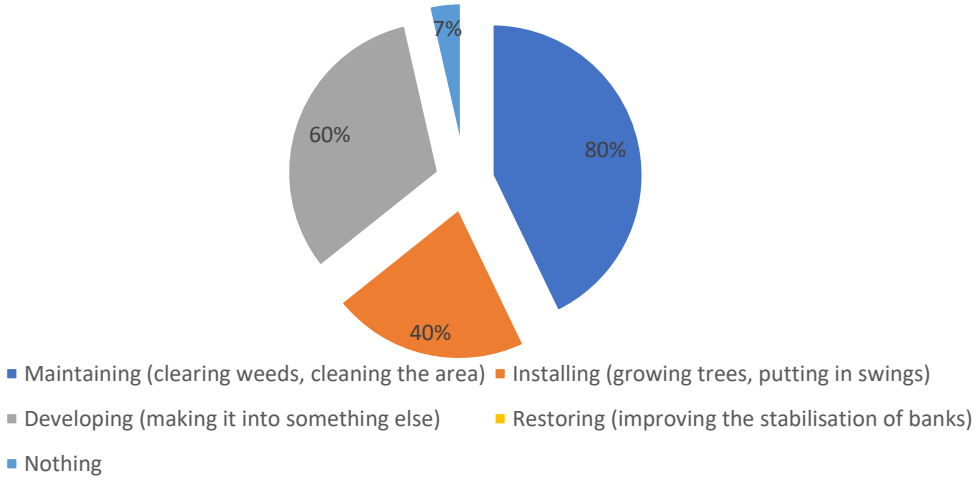
The figure shows a total of 80 % of respondents indicated there has “definitely been a change” in GI in the last ten year, while 13% indicated there has “probably been a change”, another 7% there probably has not been a change.

1.4. If the space has changed, how and why has it changed?

Recently, there has been a growth in hard infrastructure development and a decline in farming because but some Borey/flat owners leave too little space to plant home farming, especially horticulture. There has also been a growth in water pollution, the amount of solid waste increased significantly and increased traffic. UGI in Phenom Penh and public areas is still not enough. It is rare to see kind of green roofs and green walls in cities, areas for shade and cooling, creating public spaces to bring the family to relax stress and exercise, while making the city beautiful. Yet, there has been some positive change, with the Royal Government considering the development of resources and the environment more carefully, with GI incorporated into new developments for a better life and to grow businesses. Reasons for these changes related to the fact that currently Cambodia is developing rapidly; road infrastructure or other structures (both public and private) are changing rapidly; growing land demand to increase the economy; population growth; and a lack of public awareness of the benefits of GI.

1.5. What activities are people undertaking to conserve their local green-blue spaces?

Figure A2. Activities related to local green-blue spaces (% of 15 interviewees)



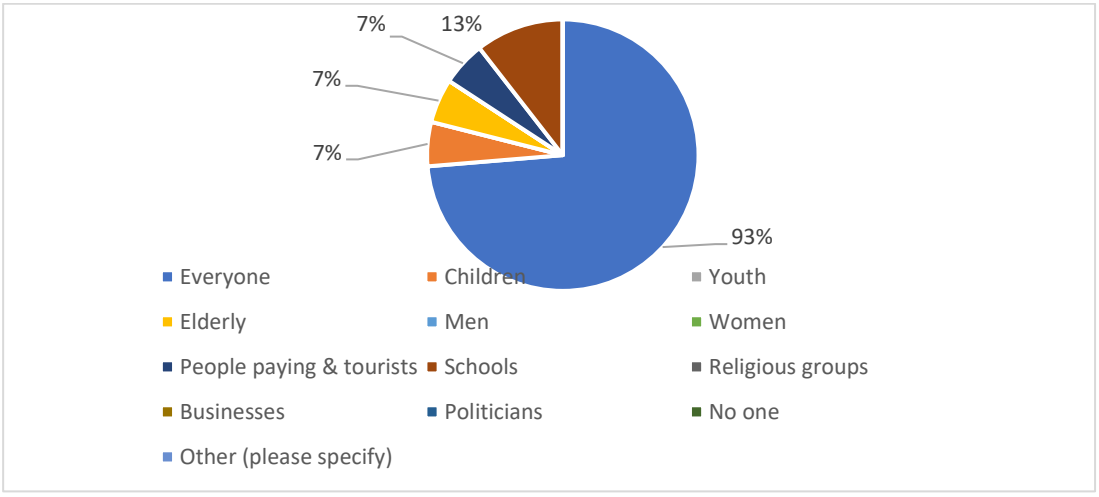
Notes: Nothing includes urban waste management, resource recycling, energy saving and environmental improvement. Restoring accounts for 40%.

1.6. Please describe why you gave the above answer.

Activities to maintain UGI include: the nation has obligations with the Royal Government and local authorities to improve GI and participation in tree planting (one person, one tree), social media campaigns, an action plan for public participation, capacity building and waste collection to improve health. Due to such actions, much of the infrastructure is clean, including in front of Wat Botum and the Royal Palace. People are undertaking these activities because they want to have nice environment, get enough oxygen, fresh air, cooling from more trees, exercises, relax from stress and prevent flooding. They want to live in a city or an area where the environment is clean, tidy, no litter, no pollution. Residents want to maintain beauty and aesthetics for a healthy environment, are driven by their love for living a green environment and understand more about the benefits of GI for the city. GI also serves as biological nets (synthesis of biology on the ground, prevent erosion, slope, drainage system and strengthen the soft soil), as biological reservoirs (flood resistant plants), conserving energy and ais food security through agriculture.

1.7. Who uses this GI?

Figure A3. Users of GI (% of 15 interviewees)



2. Evaluating current risks and the role of nature-based solutions response to risk of disasters

2.6. Where are the riskiest areas in the city to these risks?

The most vulnerable areas are downtown (along the river, south and west of the city), low lying areas where there the drainage system becomes blocked with heavy rainfall causing flooding, other areas where there are epidemics and natural disasters, where the heat flow is blocked, crowded areas in the city centre and areas with a lot of squatter structures. Frequently sited areas considered the riskiest are: Chomchao market, Klang Romsev market, Boeung Kak, Kour Srov, national road 4, Banteay Meanchey Battambang, Street 2004, Khan Meanchey, Steung Meanchey, Depo market, Boeung Tumpun, Kobsrov, Dongkor, Teuk Laak, Tep Phorn, Sen Sok, Phnom Penh Thmei Kombol and Mondial.

2.7. What were the public and private responses to address the risk?

To reduce risk and adapt to climate change, the public and private sectors help high risk flood victims find safe shelter, first aid and other diseases, rebuild infrastructure and offers food aid using private funds, or in the form of daily food allowances. The government is further working on improving the drainage system. Nevertheless, the government does not really focus on GI. Yet more involvement from the government is needed to prepare for risk, not only emergency response and develop the society. The government should manage and prepare in advanced on how to deal with natural disasters to avoid properties damage. Ministry of Tourism has raised the topic of “one person, one tree” and attract tourists to the city. The Ministry of Land Management should have strict policy for green projects investor when construction permits are not granted. State institutions need to continue to enact laws, response measures and incorporate climate change issues into national and sub-national and socio-economic development policies and plans. Integrate and enhance knowledge on the above risks through internal and external education. Institutions should have better development and implementation of GI. Private companies should give donations, as should the public for big trees in the city.

2.8. How would you like the responses like to improve in the future?

In the future, we would like to see a city with streetlights, wide and clean roads, with wildflowers, open fields, vegetable farming in front of homes, greenery everywhere. We want a city without floods, dust, blocked drains, garbage, traffic and without a bad odour. Looking forward, the transformation of GI in the next ten years is possible through the planning, development and maintenance of towns, transport infrastructure and the development of existing natural systems in the region (local landscaping, drainage systems, habitats and biodiversity). Respondents would also like to see community greening campaigns- planting, maintaining and regularly improving GI such as trees, gardens, ponds, or green areas. The education sector should integrate and knowledge awareness, encourage participation in responding to climate change more widely, accompanied by public education campaign of GI through primary, secondary and tertiary education institutions and raise awareness television and media broadcasts. The government should improve the solid waste management system, while upgrading the sewer drainage and storm water system to improve water flow and prevent flooding. NGOs and others should enforce GI. The government should provide the land for people to plant more trees, as well as protect existing forests and stop deforestation. Governments should be prepared and act pre-emptively to prevent risks and adapt to climate change, Government should improve their planning in advanced and reduce sedimentation of ponds and rivers to reduce flooding.

3. Evaluating the benefits derived from green infrastructure

3.6. ***For the following benefits, under each section please rank your level of priority of the types of benefits you would like to receive from green infrastructure. Please use score from 1-5 with 1 being most important, five being least important.***

Benefits	Importance
Reduce noise pollution by damping traffic, train and plane noise	100.00
Improve the walkability and "bike ability" of the city	100.00
Reduced combined sewer overflows	93.33
Reduce smog (nitrogen oxides, volatile organic compounds, heat, sunlight) causing respiratory problems	93.33
Make the city more pleasant scenery and beautify the city	93.33
Water infiltration and replenish groundwater reserves	86.67
Reduce pathogens, nutrients, sediment and heavy metals in water	86.67
Slowing and reducing storm water discharge	86.67
Reduce pumping and treatment demands for municipalities	86.67
Carbon sequestration	86.67
Filtering dust, chemicals and metals suspended particulate matter	86.67
Reduce urban heat island effect	86.67
Create more social inclusion and sense of community by having places to socialize	86.67
Improve mental health	86.67
Encourage outdoor physical activity, reducing obesity and preventing associated chronic diseases	80.00
Promote urban liveability, urban comfort and satisfaction of living in the city	80.00
Reducing emissions associated with air conditioning	73.33
Reducing dependence on embedded carbon in materials for construction of the built environment	73.33
Flood mitigation	73.33
Relieving stress on local water supplies and improving the quality of potable water	66.67
Improve a healthy indoor environment	66.67
Energy efficiency	60.00

7.4 Annex 2 Examples of approaches of GI and benefits in other countries

Urban green infrastructure	Solutions	Examples	Public and business effects
Green roofs	Planting stormwater, native and drought tolerant trees, green roofs and vegetation (e.g., shrubs, grasses, groundcover)	Vegetation that reduces the urban heat island effect by shading buildings, deflecting radiation and releasing moisture into the atmosphere, reducing paved surfaces in public spaces (e.g., in streets, sidewalks, vacant lots, squares, along roadsides), increasing infiltration and roadside cooling.	Reduce energy costs for air conditioning, access to tax credits for installing green roofs, reputational and aesthetic gains.
Verge channelised rivers or streams	Constructed wetlands	Wetlands that remove pollutants and excess nutrients before wastewater is discharged into the environment.	Improves the quality of water before discharged to the environment, while creating natural landscapes in urban areas, protecting infrastructure from floods, improving cost effectiveness, avoiding water contamination when the combined sewer overflow is higher than expected, useful in rural and older cities (where domestic and municipal wastewater, runoff and stormwater are collected in the same pipe network.
	Treatment channels	Channels are used to treat industrial water, by strategically placing rocks within naturally occurring streams, lining channels with limestone to naturally balance acidic waters without using chemicals.	
Raingarden	Bioswales	Shallow ditches which protect nearby water bodies and capture stormwater runoff from impervious surfaces.	Mitigates against localized flooding which reduces foot traffic, causes infrastructure damage and increases water pollutants. Store stormwater in urban areas, which can be reused for the irrigation of green spaces.
	Bioretention ponds	Strategically placed bioretention ponds with soils and plants to remove water pollutants while storing stormwater until it infiltrates the ground or evapotranspires.	
	Rain gardens	Depressed areas vegetated with grasses and other perennial plants that collect, slow and filter rainwater.	
Public garden	Strategic planting and erosion control	Buffer strips of native vegetation around fields, xeriscaping (e.g., less irrigation).	Used to remediate sites, control nonpoint source pollution, increase drought resiliency, lower maintenance costs, generate revenue from produce, reduce pressure on competing land uses, reduce food miles travelled, recycle resources, regulate buildings' temperature, link consumers to production and design innovation, less pesticides and associated emissions, social facilities and improve community food security to a limited degree depending on soil quality and local pollution.
	Bioengineering	Wetland vegetation, pollinator habitat and habitat enhancement for bat and avian species.	
	Local food production	Vertical farming, green rooftops, rooftop greenhouses, indoor farms and community gardening.	

(Adapted from Thorn et al., 2021)

7.5 Annex 3 Questionnaire for key stakeholder consultation

Objective 1. Demonstrate the impact of UGI initiative (For Institutional stakeholders only)

1. Please describe **one example of an investment in green infrastructure in Cambodia** which have a good understanding of. Give the name of the project, where it was and briefly describe the project.

Please select the most appropriate category for the following features of the project. Although these are not mutually exclusive categories, please select one answer for each category.

4. Design features ▪ Bioretention area ▪ Constructed stormwater wetlands ▪ Permeable pavements ▪ Grassed swales ▪ Grassed filter strips ▪ Rainwater harvesting ▪ Green roofs ▪ Riparian buffers ▪ Rain gardens ▪ Curb cuts ▪ Biochar ▪ Biosolar ▪ Other (please specify)	**5. Type of facility (habitat type)** ▪ Institutional/educational, government complexes, public facilities ▪ Open spaces, parks, gardens ▪ Transportation corridors, streetscapes, parking lots ▪ Mixed use ▪ Industrial use ▪ Commercial use ▪ Residential use	**6. Type of benefit** ▪ Air noise pollution ▪ Biodiversity ▪ Amenity ▪ Rainwater runoff control and water infiltration ▪ Urban temperature/ evaporative cooling and shade ▪ Carbon sequestration ▪ Landscape aesthetics ▪ Enhanced economic capacity ▪ Food provisioning ▪ Health benefits and labour productivity ▪ Increase potential for domestic and international tourism ▪ Climate change adaptation
7. Area of green spaces for managing stormwater ▪ 0.047 ha or less ▪ 0.047 ha–0.405 ha ▪ 0.405 ha–2.023 ha ▪ 2.023 ha or more	**8. Estimated project cost** ▪ USD 100,000 or less ▪ USD 100,000–USD 500,000 ▪ USD 500,000–USD 1,000,000 ▪ USD 1,000,000 or more	**9. Project type** ▪ Part of a new development ▪ Part of a redevelopment project ▪ A retrofit of an existing property
10. Time horizon ▪ Past project ▪ Ongoing ▪ Planned	**11. What was the lifespan of the project (years)?**	**10. Please describe some of the strengths of the project?** **10.**
11. What were some of the challenges, weaknesses, or barriers? (e.g., path dependency; social acceptance and perceptions of values of residents; institutional arrangements; governance / partnership coordination; uncertainty about the delivery of benefits; lack of engineering standard; resistance to change; funding constraints; political interest or lack of will; Ineffective communication; monetizing multiple benefits, etc.)?	**12. Please describe some of the opportunities?**	**13. Please describe some of the threats of the ecosystem for scaling up of such of initiatives?**

Objective 2. Collect opinions on the current state of UGI in Phnom Penh and to guide decision in valuing potential green infrastructure investments (For Institutional stakeholders only)

1. What is your opinion on the **current state** of green infrastructure in the city?
2. What would you like to see to improve **urban planning** for green infrastructure in the city?
3. What would you like to see to improve **behaviour change** for green infrastructure in the city?
4. What would you like to see to improve in terms of **architecture** for green infrastructure in the city?
5. Please suggest what you think would be appropriate **policy regulation packages** (e.g., building codes, minimum energy performance standards) and why?
6. Please suggest what you think would be appropriate **policy incentives** (e.g., rebates and loan programmes, procurement programmes, manufacturing and innovation grants, equity programmes) and why?
7. Please suggest what you think would be appropriate **information programmes** (e.g., labelling, auditing, product registries, education and training) and why?
8. What are some the **financial sources** that you foresee to have the highest potential (e.g., green bonds, carbon credits, power generation, corporate social responsibility, municipal finances, manufacturing, eco-tourism) and why?
9. How significant is this in the **post COVID19 green recovery** and what is the potential scale green infrastructure in the post covid green reconstruction state?
10. Do you have you any recommendations of **baseline information** or data we could access which would tell us about the **current and potential status** of green infrastructure?
11. What do you think green infrastructure could do to **tourism growth** if Cambodia got more of a reputation for eco-tourism, like Bali or Costa Rica? Would this be something available as only for international luxury tourism or also for domestic tourism for residents and why?
12. What are some of the **coordination approaches to incentivise general citizen** to participate in green infrastructure programmes?
13. What **elements of decision-making tools** would you find helpful to guide you in the investment of green infrastructure on Phnom Penh moving forward, to be considered in more comprehensive phases of this assessment?

Objective 3. Establish the value and demand of existing green assets (For public panel only)

1. What do you understand by the term “green infrastructure”?

2. Please describe which of the following main types and sub-types in Phnom Penh represent existing green infrastructure initiatives?

    - Green roofs (extensive)
    - Green roofs (intensive)
    - Green walls (extensive)
    - Green walls (intensive)
    - Trees (convention street trees)
    - Trees (blue street trees)
    - Trees (afforestation *Miyawaki*)
    - Gardens (rain gardens)
    - Gardens (public parks, eg Temple (Wat) compounds, Royal Palace, children’s or urban parks and sports facilities, community gardens; Wat Botum Park)
    - Gardens (private gardens, home gardens with vegetables)
    - Gardens (ponds)

- Verges (highway, roads and sidewalks)
- Verges (swale)
- Verges (channelised verges and streams)
- Other (please specify)

3. For each of the following urban green infrastructure types, please describe what is needed in in Phnom Penh in terms of [Strongly needed; Needed; Don't know; Somewhat needed; Don't know]
    - Green roofs (extensive)
    - Green roofs (intensive)
    - Green walls (extensive)
    - Green walls (intensive)
    - Trees (convention street trees)
    - Trees (blue street trees)
    - Trees (afforestation *Miyawaki*)
    - Gardens (rain gardens)
    - Gardens (public parks, eg Temple (Wat) compounds, Royal Palace, children's or urban parks and sports facilities, community gardens)
    - Gardens (private gardens, home gardens with vegetables)
    - Gardens (ponds)
    - Verges (highway, roads and sidewalks)
    - Verges (swale)
    - Verges (channelised verges and streams)
    - Wetlands and floodplains
    - Rivers and streams
    - Rainwater harvesting systems
    - Lakes (e.g., Boeung Kak Lake)
    - Springs and fountains
    - Other (please specify)

4. Have these urban green infrastructure types in general changed in the last ten years?
    - Definitely yes
    - Probably yes
    - May or may not
    - Probably not
    - Definitely not

5. If the space has changed, how and why has it changed?

6. What activities are people undertaking to conserve their local green-blue spaces?

    - Maintaining (e.g., clearing weeds, cleaning the area)
    - Installing (e.g., growing trees, putting in swings)
    - Developing (e.g., making it into something else)
    - Restoring (e.g., improving the stabilisation of banks)
    - Nothing

7. Please describe why you gave the above answer.

8. Who uses this green infrastructure?

- Everyone
- Children
- Youth
- Elderly
- Men
- Women
- People who pay and tourists
- Schools
- Religious groups
- Businesses
- Politicians
- No one
- Other (please specify)

Objective 4. Evaluate current risks and the role of nature-based solutions response to risk of disasters (For all)

1. Please rank the most pressing climatic and non-climatic risks which you have experienced in the last 10 years?
    - Flood
    - Drought
    - Heat stress from rising temperatures
    - Storm surge
    - Typhoon
    - Irregular rainfall followed by dry spell
    - Fire
    - Lighting
    - Epidemic
    - Riverbank collapse
    - Pest outbreak
    - Overflowing sewer systems
    - Water pollution
    - Urban stormwater drainage blockages
    - Unregulated construction
    - Traffic congestion
    - Unregulated parking

2. Where are the riskiest areas in the city to these risks?

3. Please can you think about a recent flood or climate related disaster. Please can you describe what were the impacts etc?

    - Damage to infrastructure
    - Damage to bridges
    - Damage to roads
    - Disruption of social structures and networks
    - Death
    - Property damage
    - Disruption of education
    - Health centre destroyed and operations postponed
    - Damage for other farming systems

- Evacuation
- Health risks
- Labour productivity impacts
- Other (please describe)

4. What were the public and private responses to address the risk?

5. How would you like the responses like to improve in the future?

Objective 5. Evaluate the benefits derived from green infrastructure (for all, unless noted)

For the following benefits, under each section please rank your level of priority of the types of benefits you would like to receive from green infrastructure. Please use score from 1-5 with 1 being most important, five being least important.

1. What are the benefits for water quality?
   - Water infiltration
   - Reduce pathogens, nutrients, sediment and heavy metals in water
   - Replenish groundwater reserves
   - Slowing and reducing stormwater discharges
   - Reduce pumping and treatment demands for municipalities
   - Reduced combined sewer overflows

2. What are the benefits for air quality?
   - Filtering dust, chemicals and metals suspended particulate matter
   - Reducing power plant emissions associated with air conditioning
   - Carbon sequestration
   - Reduce smog (nitrogen oxides, volatile organic compounds, heat, sunlight) causing respiratory problems

3. What are the direct and indirect jobs and investment benefits? (For institutional stakeholder only)
   - Increase land property values, benefiting both developers and homeowners
   - Tourism
   - Lower capital costs for developers
   - Provide income to local communities
   - Promote skills, training and certification
   - Create new direct jobs (e.g., Recreation and leisure, park maintenance, storm water management, construction)
   - Create indirect jobs (e.g., accommodations and restaurants; waste energy transfer systems or biofuels)
   - Saving the energy costs for air conditioning due to lowering temperature
   - Lower building energy demand and use through cooling and shading
   - More vegetables and fruits for local communities
   - Resource saving in the construction of energies
   - Improve labour productivity

3a. For the above, do you any ideas about jobs involved in the installation and maintenance of the green infrastructure? (for institutional stakeholder only)

4. What are the climate resiliency and adaptation co-benefits?

- Reduce urban heat island effect
- Low carbon development (embedded carbon in materials for buildings)
- Energy efficiency
- Flood mitigation
- Relieving stress on local water supplies and improving the quality of potable water
- Other (please specify)

5. What are the health and wellbeing benefits?
    - Improve mental health
    - Improve satisfaction of living in the city
    - Encourage outdoor physical activity, reducing obesity and preventing associated chronic diseases
    - Reduce noise pollution by damping traffic, train and plane noise
    - Improve a healthy indoor environment
    - Improve the walkability and "bike ability" of the city
    - Promote urban liveability and urban comfort
    - Create more social inclusion and sense of community by having places to socialize
    - Make the city more pleasant scenery and beautify the city

Objective 6. Demands for GI (For developers, policy makers and private companies only)

1. What is are the key GI that are most needed by your clients? Please describe?
2. How do you get these ideas of GI infrastructures?
3. What are the additional costs of incorporating these GI infrastructures into your projects?
4. How do you see these GI trends over next 10 years?
5. Of the existing policies in Cambodia related to UGI (see table 5 for examples) which do you think have been effective and or not? Please explain why.
6. What are some of the main barriers or challenges for mainstreaming UGI in Cambodia (see table on barriers)?
   What are appropriate enablers or responses to overcome these barriers to secure this future?

[i] http://www.tdag.org.uk/uploads/4/2/8/0/4280686/15.06.22_the_stockholm_system_bjorn_embren.pdf
[ii] http://akiramiyawaki.com/research-and-development/international-applications/
[iii] https://c40-production-images.s3.amazonaws.com/other_uploads/images/1963_AD-Ref_Singapore_Bishan-Park.original.pdf?1538133801