Valuing the benefits of Nature-based Solutions for Integrated Urban Flood Management in the Greater Mekong Region

STREETSCAPE GREENING TRANSFORMATION OF RAYONG'S CENTRAL BUSINESS DISTRICT

CASE STUDY REPORT

February 2022

Prepared for: **AWP, DFAT, World Bank, Rayong Municipality**

Prepared by: **CRCWSC and ICEM**

Australian Aid | THE AUSTRALIAN WATER PARTNERSHIP | WORLD BANK GROUP | GWSP GLOBAL WATER SECURITY & SANITATION PARTNERSHIP | icem | CRC for Water Sensitive Cities

DISCLAIMER

This document was prepared by the Cooperative Research Centre for Water Sensitive Cities (CRCWSC) and the International Centre for Environmental Management (ICEM) for the project *Valuing the Benefits of Nature-Based Solutions for Integrated Urban Flood Management in the Greater Mekong Region* for the Australian Government Department of Foreign Affairs and Trade (DFAT), and the Australian Water Partnership (AWP). The views, conclusions and recommendations in the document are not to be taken to represent the views of DFAT and AWP.

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In Thailand, the project is hosted by the Office of Natural Resources and Environmental Policy and Planning (ONEP) and Rayong Division of Public Works. The project team also extends our thanks to the other government agencies who guided and informed the project: Bangkok Metropolitan Authority (BMA), the Office of the National Economic and Social Development Council (NESDC) and the Office of National Water Resources (ONWR).

Executive summary

The vision for this case study is streetscape transformation throughout Rayong City's Central Business District incorporating a network of green assets to improve thermal comfort, mitigate flooding and increase natural infiltration.

Rayong is Thailand's leading industrial hub, with the nation's highest per capita GDP. Under the Eastern Economic Corridor Development Plan (EECDP), Rayong will be the focus of accelerated economic growth, with the region envisaged as an arterial hub for trade, investment, research and innovation, and regional transportation. To support this growth in a way that protects the environment and the health and wellbeing of communities, a business-as-usual approach will no longer be sufficient. The strategy outlined in this case study brings nature-based solutions (NbS) to Rayong's central business district (CBD) through:

1. **Water sensitive urban design on primary roads** to create a green transport network and improve flood management on critical transportation routes
2. **'Urban canyons'** on key commercial/neighborhood streets to increase canopy cover and improve thermal comfort
3. **Green, cool shopping hubs** via rainwater harvesting tanks on roofs of large commercial buildings to mitigate flooding and reduce combined sewer overflow
4. **Greening of low-lying public space** such as car parks to improve thermal comfort, increase natural infiltration and reduce localized flooding
5. **Rayong 'Cool Lines' smart platform** to enhance local and tourist experiences, allowing visitors and residents to find the greenest and coolest routes.

Results of this strategic assessment suggest a strong overall benefit–cost ratio (BCR) of 9.7 over a 20-year period; i.e. for $1 invested, more than $9 will be returned in community benefit. This is equivalent to a net present value (NPV) of around USD 31 million. This result shows NbS assets can create significant value for a broad range of urban stakeholders, including local communities, commuters, visitors, the private sector and government implementing agencies (Rayong Municipality, the Department of Highways and the Department of Rural Roads).

The case study also highlights the advantages of a phased approach. The strategy includes retrofitting primary roads at 5-year intervals, concluding with Sukhumvit Road in 2036. This approach allows for testing and adapting NbS strategies to Rayong conditions, reducing risk, spreading out costs and integrating with regular planned maintenance works. The approach also enables trust in the measures to build and learning from initial phases to inform future development, including potential national level building code reform.

Engaging the private sector will be essential – including small businesses and local communities in Rayong's CBD, as well as on a regional scale as part of possible Corporate Social Responsibility (CSR) contributions. While strategic rather than definitive, this case study assists this engagement by providing information on the possible type, value and distribution of benefits. Several creative methods of engagement emerged from discussions in Expert Exchange sessions. An example is building on local beliefs by planting a family tree to incentivize urban greening efforts and partnerships with the Ministry of Culture. Avenues for 'polluter pays' and 'beneficiary pays' funding options were also explored. Expert Exchange sessions also supported the view that greening and cooling of the CBD will not only make Rayong more liveable for residents, but also attract businesses and talent

in line with the region's hi-tech ambitions, and promote revitalization of the region's tourism sector as part of the COVID-19 recovery strategy.

Finally, the case study adds to a growing list of practical applications of a 5-step Integrated Urban Flood Management (IUFM) framework in the Greater Mekong region. For information on the IUFM methodology see the IUFM Manual.

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Abbreviations

ARI	average recurrence interval
AQI	air quality index
AWP	Australian Water Partnership
BCA	benefit–cost analysis
BCR	benefit–cost ratio
BMA	Bangkok Metropolitan Administration
CBD	central business district
CCMC	Climate Change Management and Coordination Division
CRCWSC	Cooperative Research Centre for Water Sensitive Cities
CSR	Corporate Social Responsibility
DFAT	Australian Government Department of Foreign Affairs and Trade
EEC	Eastern Economic Corridor
EECDP	Eastern Economic Corridor Development Plan
FAR	Floor Area Ratio
GHG	greenhouse gas
ICEM	International Centre for Environmental Management
INFFEWS	Investment Framework for Economics of Water Sensitive cities
IOT	Internet of Things
IUFM	Integrated Urban Flood Management
NAP	National Climate Adaptation Plan
NbS	nature-based solutions
NESDC	Office of the National Economic and Social Development Board
NESDP	National Economic and Social Development Plan
NGOs	non-government organizations
NPV	net present value
OECD	Organisation for Economic Cooperation and Development
ONEP	Office of Natural Resources and Environmental Policy
ONWR	Office of National Water Resources
PPP	public–private partnership
UNFCCC	United Nations Framework Convention on Climate Change

Project background

Now and in the future, cities need integrated solutions to complex challenges. Floods are the most frequent natural disaster globally, and cause more damage than any other weather or non-weather-related event. And flood-related damages are expected to grow, driven by urbanization, land use changes and climate uncertainty. Compared with conventional 'gray' infrastructure by itself, nature-based solutions (NbS) such as wetland parks, raingardens, bioswales, green roofs and walls, can involve less upfront investment, can be more scalable and flexible and generate a range of environmental, economic and social co-benefits beyond flood management.

A range of innovative hybrid approaches to integrated urban water management are already operational across the Asia–Pacific region. The increasing recognition of hybrid approaches that integrate NbS reflects the changing nature of societies across Asia and the increasing aspirations for improved environmental quality, community health and economic prosperity. However, sometimes it can be difficult for decision makers to justify using NbS, or hybrid solutions compared with conventional measures.

Responding to this challenge, the Cooperative Research Centre for Water Sensitive Cities (CRCWSC) and the International Centre for Environmental Management (ICEM) have been working closely with national government agencies in Thailand and Vietnam to identify and evaluate the full range of market and non-market benefits of NbS, as well as considering appropriate financing and investment models.

The CRCWSC has developed and trialed the innovative Investment Framework For Economics of Water Sensitive cities (INFFEWS) which comprises a Benefit–Cost Analysis (BCA) Tool and a Value Tool that support application of current research on non-market values to new contexts. These tools have been trialled extensively in Australia as well as in several cities in China. The current project now applies them to the greater Mekong region, focusing on Thailand and Vietnam. Four detailed case studies across Thailand and Vietnam demonstrate the Integrated Urban Flood Management process and the assessment including quantifying market and non-market benefits of NbS in monetary terms.

Case study methodology

Each case study follows the 5-step IUFM process for identifying, valuing and choosing an appropriate mix of flood management interventions for a particular context.

Benefit–cost analysis (BCA) was adopted because it is a rigorous and accepted methodology for comparing the value to the community of different options. BCA can be used for a range of purposes including initial scoping of strategic concepts, detailed comparison of options, and review of whether a project, program or regulation has delivered the promised benefits. This analysis assesses the proposed strategic concepts.

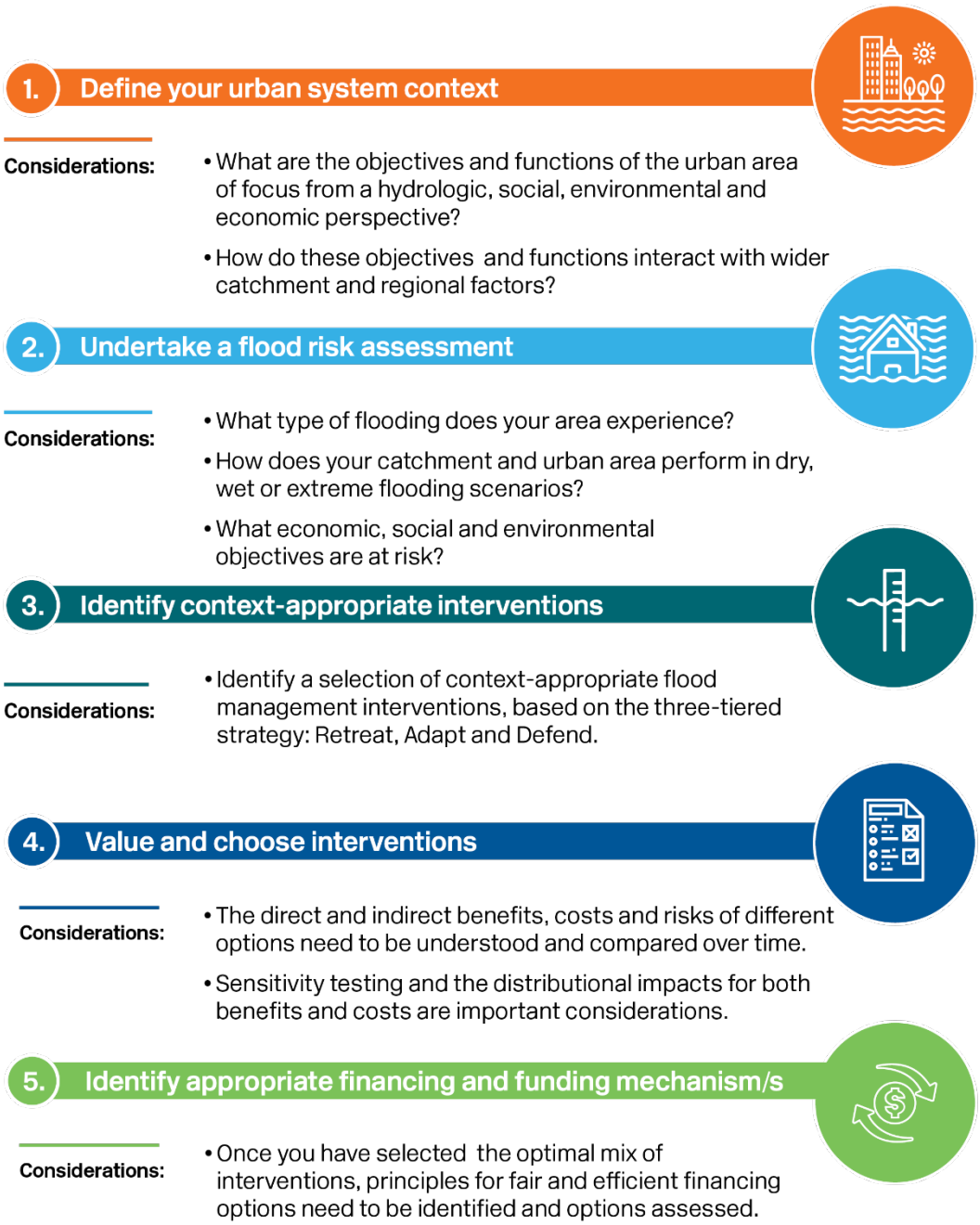


Figure 1: IUFM process.
Source: Project team.

The case study began with site visits and consultations with municipal authorities in Rayong City to define the case study site, prioritize urban challenges and understand potential for NbS. Baseline information, particularly regarding Step 2 – flood risk assessment and climate change implications was supplemented by findings from the ICEM project *Strategic Environmental Assessment (SEA) of Rayong Provincial Development Plan and Revision of the Thai Draft SEA Guidelines*. Context-appropriate interventions were developed based on national and international best practice and the expertise of the project team.

Cost estimates of the hybrid solutions were developed, based on national data and cost norms, supplemented where there were gaps by data from other countries in Asia. A previous study on valuing the benefits of NbS for IUFM in Kunshan, China was a key resource.[1] Next, the benefits were estimated, using a mix of market values (e.g. avoided costs of infrastructure investment and estimated reduction in travel delays from flooding), and value transfer from the INFFEWS Value Tool[2] to quantify improved amenity, environmental improvements (based on willingness to pay studies), and increased property values (based on hedonic pricing studies).

Another important consideration in the methodology is how benefits and cost change over time. Some benefits may be one-off, such as increases in property values. Other benefits will build over time, such as avoided flood damage. It is also important to build local technical and financial capacity to maintain assets so they continue to deliver value, as well as defining who will be responsible for maintenance. Additionally, the model recognizes benefits are more valuable now than in say 5, 20 or 40 years' time. The time value of money – or the 'discount rate' is usually set according to national standards, and commonly ranges from 2–6%. In this case, we assumed a discount rate of 4%, but the range adopted for sensitivity testing includes the current government bond yield of 2.4%.

After the cost and benefit information was added to the model, an important final stage was sensitivity testing. This stage asks how strong the conclusions are when significant changes are made to the assumptions. In cases such as these where the BCA is strategic, without precise costs and benefits, undertaking this step is important for establishing the validity of findings. In this case study, sensitivity testing involved increasing and decreasing costs and benefits by 30%, running the model 1,000 times and building a distribution of probabilities. Similar sensitivity analysis was done for different discount rates and key assumptions such as the take up rate of small scale NbS by private parties and the period of analysis. Results of the sensitivity testing are presented in Chapter 4.

Financing and funding recommendations were formulated based on international and national good practice and innovation. In particular, this study considered the existing national Floor Area Ratio (FAR) bonus scheme, as well as information on the distribution of costs and benefits from the BCA model, to support discussions about efficient and fair ways to distribute costs.

[1] Wishart, M., Wong, T., Furmage, B., Liao, X., Pannell, D. & Wang, J. (2021). *The Gray, Green, Blue Continuum: Valuing the benefits of nature-based solutions*. Washington DC: World Bank.

[2] The INFFEWS (Investment Framework for Economics of Water Sensitive Cities) tools were developed by the CRC for Water Sensitive Principles, as part of its Integrated Research Project 2 (Comprehensive economic evaluation framework). Further information is available here: https://drive.google.com/file/d/1f_cbHpOWToeAA63qbnsEml89v0phVu4a/view?usp=sharing

Stakeholder engagement

Strong stakeholder engagement and co-creation of solutions was critical to the case study approach. As well as promoting IUFM approaches, the project's parallel goal was to build capacity and create a community of practice of national champions who have the necessary tools and knowledge to identify, evaluate and quantify NbS within a robust economic framework.

A key initial action was forming a high-level Steering Committee with relevant Thai government stakeholder agencies. The Committee was chaired by the Office of Natural Resources and Environmental Policy and Planning (ONEP) with a core mandate of climate adaptation policy. Other agencies involved were the Bangkok Metropolitan Authority (BMA), the Office of the National Economic and Social Development Board (NESDC) and the Office of National Water Resources (ONWR).

Three workshops were held, with invitees from each of the Thai Steering Committee agencies involved in the study, as well as other relevant agencies such as Department of Groundwater Resources, Department of Public Works and Town and Country Planning, Rayong Subdivision of Sanitary Works, Royal Irrigation Department, and academic and research institutions (Thailand Environment Institute, Mae Fah Luang University, Mahidol University). The same participants were invited to each event to ensure continuity of learning outcomes and to support the development of a community of practice:

- **1. Foundational training for national stakeholders (8–9 February 2021):** This 2-day event provided a high-level overview and introduction of the topics, including examples of NbS as multifunctional water infrastructure in Australia, China and Thailand. The session also introduced the case studies, covering Steps 1 and 2 of the IUFM process and seeking feedback on whether the project team had adequately understood the local context and issues faced. The event covered both Rayong and Sukhumvit case studies.

- **2. Identifying Integrated IUFM and NbS Interventions (22–23 March 2021):** The second session focused on the Step 3 of the IUFM process, presenting the hybrid solutions and the anticipated benefits. Key questions put to stakeholders focused on local feasibility, whether the solutions adequately responded to the issues identified in the previous phase, and whether the benefits were accurately described. The event covered both Rayong and Sukhumvit case studies.

- **3. Valuing and comparing IUFM solutions (1 October 2021):** The final session focused on Steps 4 and 5 of the IUFM process, presenting the results of the BCA analysis, and outlining potential modalities for funding and financing. A key goal was to test the assumptions in the model with participants to ensure their appropriateness. Two separate workshops were held for each of the 2 case study locations, although participants from Rayong joined the Sukhumvit workshop and vice versa.

1. Define your urban system context

1.1 Rayong Province – sleepy backwater to thriving industrial hub

Before 1980, Rayong Province was sparsely populated, with an economy driven by agriculture and fisheries. The discovery of large quantities of natural gas in the Gulf of Thailand in the mid-1980s led to fundamental changes in the region's economy and demographics. Rayong's industrial areas are now home to more than half of Thailand's oil refining capacity, more than 90% of the petrochemical capacity and around 25% of national electricity generation capacity, as well as automotive, electronics and bio-technology industries. This shift from production in primary sectors to service and industrial sectors means Rayong now has the highest per capita GDP in Thailand, almost double that of Bangkok.

Under the Eastern Economic Corridor Development Plan (EECDP), approved by the Thai legislative Assembly in 2018, the eastern provinces of Chachoengsao, Chonburi and Rayong will be the focus of accelerated economic growth, including new industrial areas, new urban centres, expanded ports and airports and new railway lines. The goal is to develop the region as an arterial hub for trade, investment, research and innovation, and regional transportation. Under the EECDP, new motorways, high speed rail and the refurbished U-Tapao international airport will make connectivity in Rayong area even easier. The implications of this plan include expanded employment opportunities, particularly in high-tech industries such as robotics and avionics, as well as continued expansion of Rayong City. In 2017, Rayong was named 'Asia-Pacific City of the Future' by the Financial Times largely due to this economic potential.

Figure 2: Thailand's Eastern Economic Corridor.
Source: Straits Times.

But Rayong is not just factories and motorways. Its significant economic growth has also been driven by a booming tourism industry. Rayong City is an easily accessible destination from Bangkok with long sandy beaches and coastal attractions nearby, as well popular islands like Koh Samet. However, rapid population growth, industrial development and limited controls on pollution have also caused serious environmental challenges, which threaten fragile ecosystems, pose problems for public health and deter further growth of tourism.

The EECDP presents both opportunities and challenges for Rayong. To support this accelerated economic growth in a way that protects the environment and the health and wellbeing of communities, resolute and forward-thinking measures must be put in place to ensure sustainable development. At the same time, there are great incentives as well as economic and political capacity to showcase innovative solutions, with Rayong as the focus of Thailand's economic expansion plans, and as a globally recognized 'city of the future'.

1.2 Rayong City – urban challenges

Rayong City's population currently stands at approximately 63,406. A small, coastal city, it is known for its laid-back atmosphere, with seafood restaurants and handicraft markets as well as major transport infrastructure. However, unplanned urban growth has created challenges. Already public services such as sewerage and waste treatment do not meet demand. Rayong City is serviced by one wastewater treatment plan, which is operating below capacity due to insufficient funding in municipal budgets and issues with design and siting which prevents gravity fed inflow. As a consequence, raw sewage flows directly to the sea. Rayong also experiences high temperatures, with little tree canopy and extensive concrete coverage which exacerbates the city's urban heat island effect. Regular flooding is experienced during heavy rains, which worsens environmental and public health problems due to polluted runoff.

1.3 Case study site – Rayong City's Central Business District

This case focuses on the CBD of Rayong City in Rayong Province, Thailand (Figure 3, top). This site was chosen because it contains important community infrastructure and services such as the Rayong bus terminal, a provincial hospital, several large markets, hotels and shopping malls. The CBD also has strong potential to be developed into a landmark of Rayong, showcasing water sensitive and nature-based approaches to make the city more liveable, attract talent in line with the region's hi-tech ambitions, and revitalize the region's tourism sector as part of the COVID-19 recovery strategy.

Figure 3: Rayong City's CBD (top), case study locations within the CBD (bottom).
Sources: Google Maps/Project team.

As shown in Figure 3 (bottom) within the CBD, this case study focuses on linear assets (primary and secondary roads), private commercial assets (shopping centres) and low-lying public space (car parks), showing how a network of NbS and hybrid measures can improve flood resilience, and contribute to creating a green and cool city where people want to live and work and tourists want to visit.

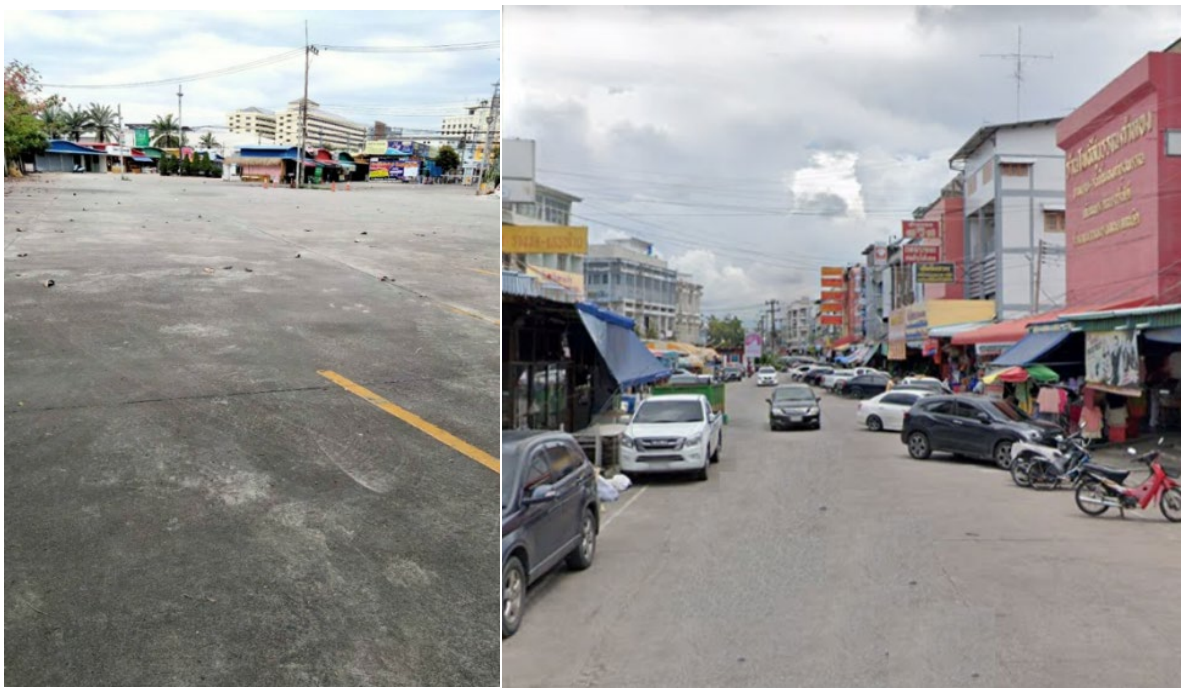


Figure 4: Area for outdoor market (location #4 on map) (left), and shopping street (location #5 on map) (right).
Source: Project team, December 2020.

Within the case study site, responsibility for infrastructure and land ownership is complex. In Rayong's early years more than 30 years ago, development of the CBD was largely driven by private business that created road networks, drainage and sewerage to support the sale of their merchandise and services. Since then, secondary roads and basic infrastructure in the CBD are regularly improved and maintained by Rayong Municipality, although the ad hoc nature of previous infrastructure development has created challenges. Primary roads surrounding the CBD are a shared responsibility of the Department of Rural Roads (primary roads in the north), Rayong Municipality (primary roads in the east) and Department of Highways (primary roads in the south).

Land ownership in the CBD is also complex. Some land is privately owned, and under long term rentals (20–30 years). Although Rayong Municipality's mandate covers all residents of Rayong's CBD, few sites are direct owned by Rayong Municipality. The only key establishment that belongs to Rayong Municipality is the Rayong transport center which hosts public transportation for Rayong province. All commuters transit through this key hub to access the rest of the province.

Three major marketplaces host a large number of small and medium enterprises and local market product distributors. The large business operators include 2 'mega superstores'. There are also a number of hotels in the CBD.

It will be challenging to form consensus among all private businesses to invest in NbS strategies. An effective way forward may be via an engaging 'Green Rayong' strategy development process supported by a strong evidence base that shows the benefits for their businesses together with capacity building and support for action. This approach may be even more effective when aligned with existing regional and national strategies. Further information about relevant strategies and modalities for funding is provided in Chapter 5.

Other influential stakeholders who should be engaged in NbS strategy development include the Rayong Chamber of Commerce and Eastern Economic Corridor developers who will be the main contributors to future growth.

2. Undertake a flood risk assessment

Rayong Province is defined by 2 river basins running north to south to the Gulf of Thailand – the Klong Yang (or Rayong River) and the Presae River (Figure 5). The basins are bounded by hilly areas in the west, centre and east of the province. Rayong's main reservoirs are located in the upper reaches of those rivers, both of which have their source in neighboring Chonburi Province.

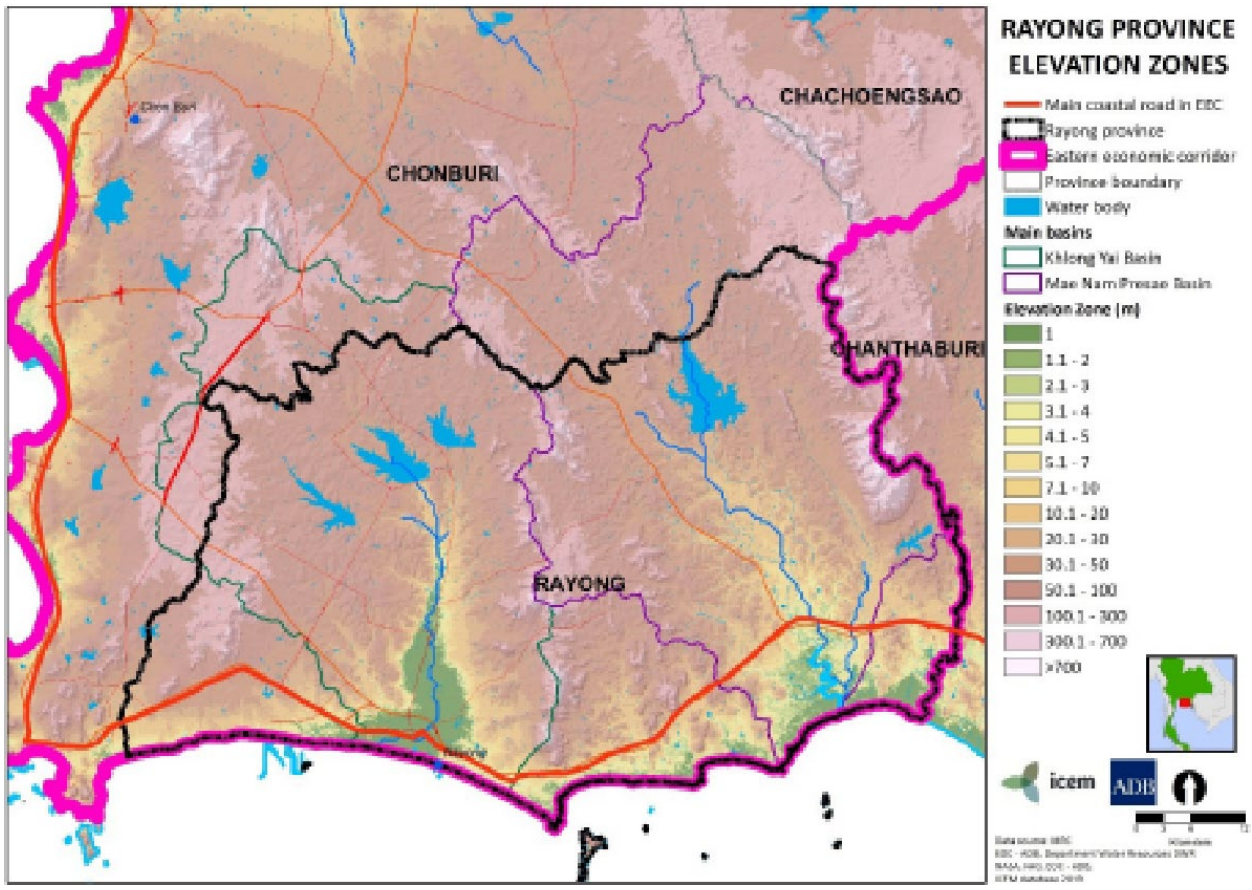


Figure 5: River basins and water bodies in Rayong Province.
Source: Project team.

Rayong experiences frequent drought and flood events, as well as coastal erosion and sea level rise. According to projections from the strategic environment assessment of the Rayong Provincial Development Plan, climate change projections to 2050 indicate more severe dry periods during the dry season and potential for more intense, extensive and frequent flooding during the wet season driven by catchment wide rainfall, storm surge and mounting sea levels.[3]

[3] NESDC, ADB and ICEM (2019). *Strategic environmental assessment (SEA) of Rayong Province Master Plan and revision of Thai Draft SEA Guidelines*. Bangkok: NESDC.

Figure 6: 2015 Flooding in Rayong: Continuous rain in the wake of tropical storm Vamco has caused landslides, swept away houses and created chaos on the roads.
Sources: The Nation/Asia News Network.

Rayong City is affected by pluvial and fluvial flooding with coastal influences. The main road – Sukhumvit Road – runs west to east dissecting the CBD. Throughout the city, rapid urban development has hardened surfaces, with extensive concrete cover and little natural drainage. Exacerbating this is the complex drainage system in Rayong's CBD: the infrastructure is old inadequately maintained, and frequently blocked (Figure 7, left). Downpipes on buildings are not connected to the drainage system, which means water flows directly from buildings onto concrete pavements and roads (Figure 7, right).

Flooding is worse on the north side of Sukhumvit Road, while water from the south side can more easily drain to the sea. However, coastal fisheries and marine life are harmed during heavy rainfall events due to a combination of sewer overflows and stormwater pollutants. This pollution also threatens public health.

Figure 7: Leaves and trash partially blocking a drain (left) and unconnected downpipe (right).
Source: Project team, December 2020.

3. Identify context-appropriate solutions

3.1 The hybrid approach

The baseline scenario in this case is 'do nothing'. The hybrid approach proposes a network of green assets to mitigate flooding, reduce urban water pollution to waterways and coastal environment, increase natural infiltration, improve thermal comfort, and create beautiful and cool spaces that can be used by residents and tourists throughout Rayong's CBD. The challenge of this approach is how to construct and maintain green assets in an already densely urbanized area which does not already have significant green spaces like public parks.

The strategy has 5 main components:

1. **Water sensitive urban design on primary roads** to create a green transport network, improve flood management and minimize disruption on critical transportation routes

2. **'Urban canyons'** on key commercial/neighborhood streets to reduce flooding, increase canopy cover, support urban cooling and improve thermal comfort

3. **Green, cool shopping hubs** via rainwater harvesting tanks and raingardens installed on or below ground of large commercial buildings including shopping centres and markets to mitigate localized flooding and reduce combined sewer overflow

4. **Greening of low-lying public space** including car parks to increase multifunctionality, support urban cooling, improve amenity and thermal comfort, increase natural infiltration and reduce localized flooding

5. **Rayong 'Cool Lines' smart platform** to enhance local and tourist experiences, allowing visitors and residents to find the greenest and coolest routes through the CBD.

As well as the benefits described above, each greening strategy would lead to significant anticipated value uplift in surrounding areas due to the improved landscape amenity and quality of open space. Additionally, the combined impact of reduced stormwater runoff and combined sewer overflows throughout the CBD would protect the coastal area against water pollution and reduce operating costs for drainage and combined sewer pumps.

3.1.1. Water sensitive urban design on roads

The strategy looked at 3 primary roads in Rayong – the main artery of Sukhumvit Road which runs throughout the Eastern Economic Corridor (shown in blue, at the southern end of the map in Figure 8), Ratchumphon Road (north), Chanudom Road (east), and several smaller secondary roads throughout the CBD shown in green.

Figure 8: Roads in the case study site (left), current design of Chanudom Road (right).
Sources: Google maps/Project team, December 2020.

Currently in Rayong, Sukhumvit Road and Chanudom Road have a vegetated median to separate the lanes and for aesthetic purposes. Ratchumphon Road does not. By retrofitting these 3 roads to depress the central median with intermittent bioretention system (biofilters) and broken kerbs (and retaining existing street trees), stormwater runoff from roads could easily drain away from buildings and pedestrian footpaths and towards the central median. Here, water would infiltrate naturally into the ground, aided by Rayong's underlying sandy soil. This proposal would also significantly reduce the amount of road runoff going into Rayong's combined sewer system, which is approaching its capacity.

During flood events, when infiltration capacity is exceeded, water would be channeled through an overflow pipe into a larger stormwater pipe underneath the median which would provide increased drainage capacity and flood protection levels. Simple biofilters would be installed between existing palm trees to treat pollutants from the road surface. The original palm trees could be preserved in this median to provide shade and for aesthetic value, and passively irrigated by the runoff.

The following cross-sections and illustrative renderings show how this strategy works and how it would look in Rayong.

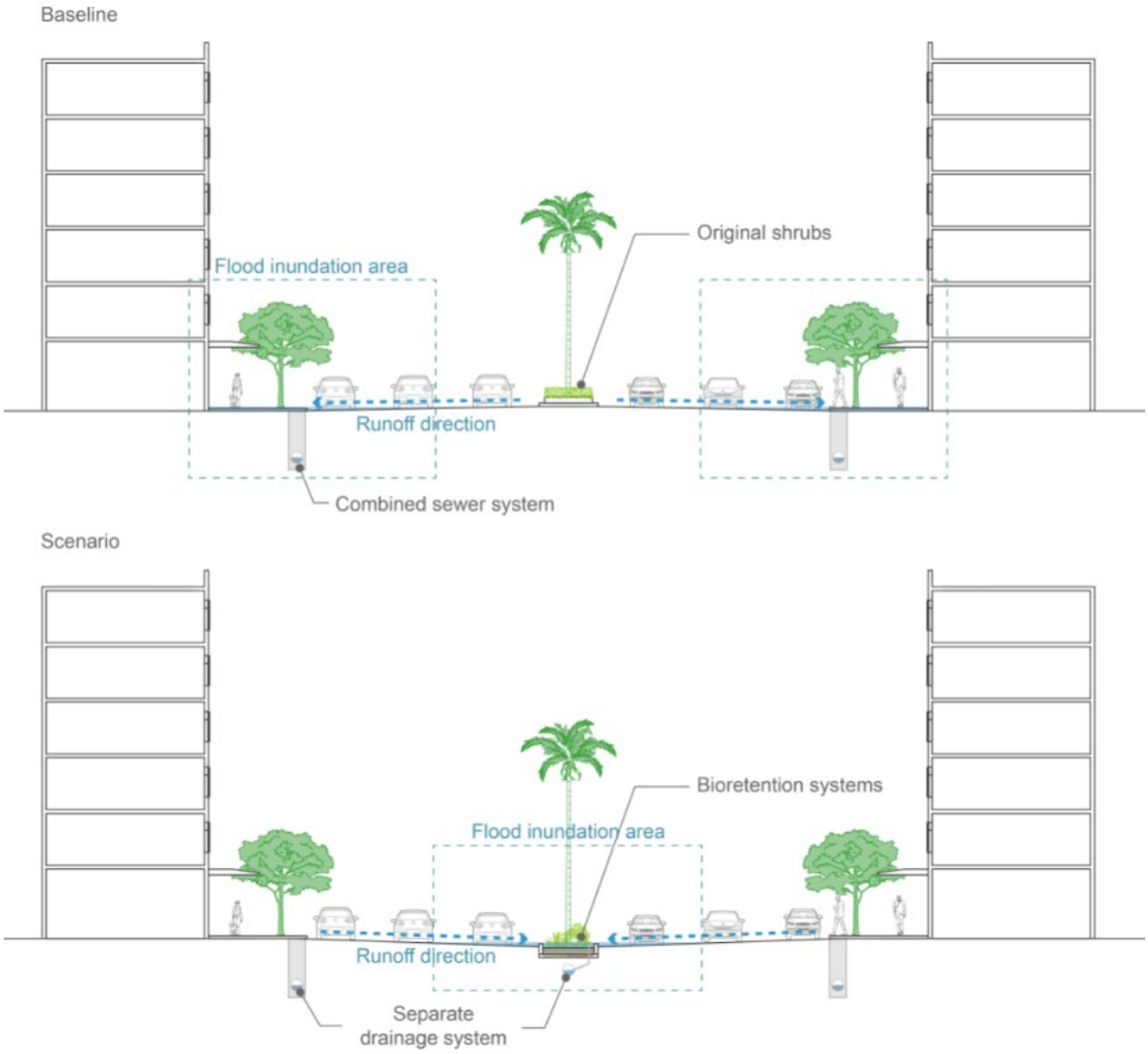


Figure 9: Cross-section of depressed median and biofiltration system for primary roads in Rayong.
Source: Project team.


INCREASED TREE CANOPY
RESERVED ORIGINAL
PALM TREES
CENTRAL MEDIAN
DEPRESSED DRAINAGE SYSTEM
BROKEN KERBS
BIOINFILTRATION
SYSTEM
STORMWATER
DRAINAGE PIPE


RUNOFF FLOWS INTO CENTRAL MEDIAN
THROUGH BROKEN KERBS
BIOINFILTRATION
SYSTEM
INFILTRATION TO
GROUNDWATER

Figure 10: Illustrative renderings of depressed median and biofiltration system for primary roads in Rayong.

Source: Tiange Wu, Water Sensitive Cities Australia.

Feedback from the Expert Exchange sessions elicited some important challenges. On primary roads such as Sukhumvit Road, the fast lane is in the centre which may be inundated during extreme events in this strategy. Stakeholders emphasized the design cannot reduce road capacity. Further, it would be difficult for Rayong Municipality to carry out any changes to primary roads because it would require updates to building codes at the national level.

Responding to this feedback, the project team noted traffic tends to slow in wet weather conditions regardless of road design. With the hybrid strategy, road ponding is channeled into the overflow pipe in the central median, rather than into shops and houses. In extreme conditions, only the inner land would be inundated, leaving the outer two lanes dry. In dry conditions, all 3 lanes would be preserved. Education and signage would support wet and dry usage of the road and would be consistent with general messages around the importance of not entering flood waters.

Regarding updates to building codes, the strategy phases the road upgrades, starting with selected secondary roads, and Chanudom Road as the first primary road (more information on phasing is provided in Table 1 in Chapter 4). This phasing allows the benefits and technical feasibility of such an approach to be verified. Learning from this phase could then inform future phases and rollout at scale, with Rayong leading the way for local and national building code updates if the pilot phase is successful.

In the strategy, construction works for the largest road – Sukhumvit Road– are not planned until 2036 to allow for piloting on less critical roads, which could include a further BCA to compare the roads with and without the intervention. Further, upgrading works should be staged wherever possible to fit in with planned road renewal to minimize disruption and additional costs. For this study we assumed 3 primary roads to be upgraded in total (Chanudom, Ratchumphon and Sukhumvit) with one retrofitting per 5-year budget cycle.

3.1.2. Urban canyons

‘Urban canyons’ refer to a streetscape greening approach. There are 2 key ideas for Rayong’s CBD: stormwater planter boxes and pop-up gardens along secondary roads.

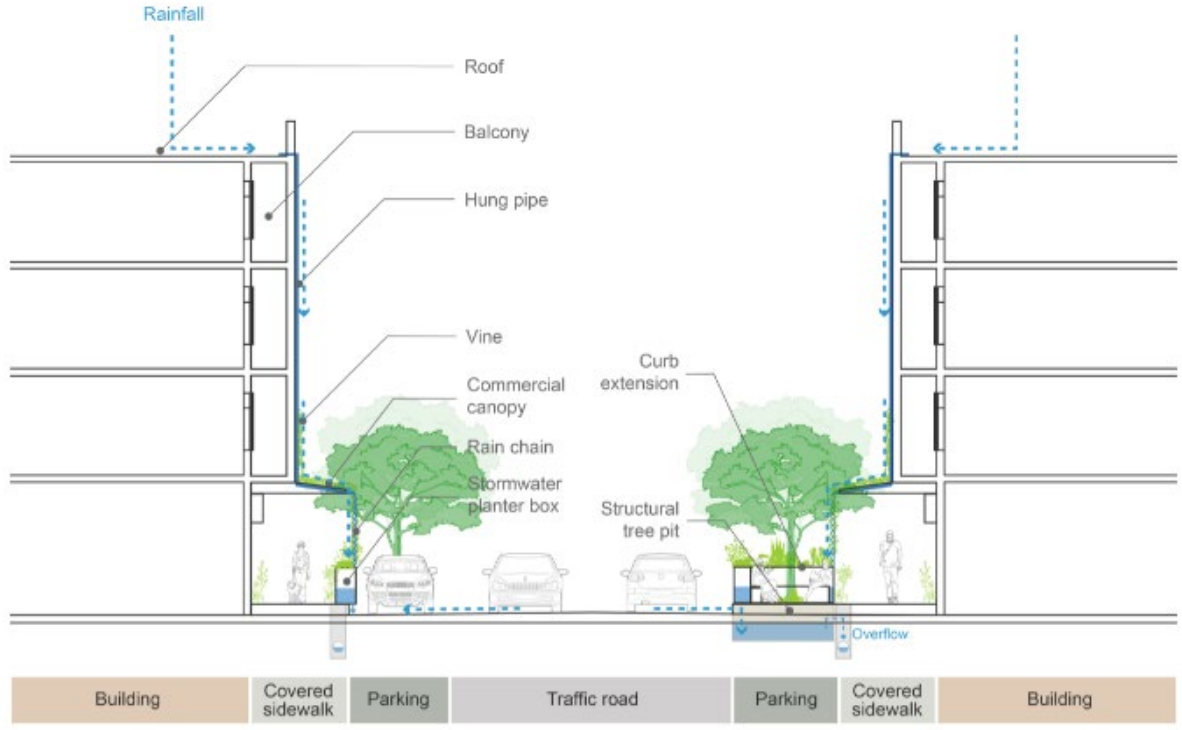


Figure 11: Cross-section showing urban canyon design.
Source: Project team.

Figure 12: Commercial street in Rayong's CBD showing downpipes ending at commercial canopy level (left) and stormwater planter box (right).
Sources: Project team, December 2020 (left), Water Sensitive Cities Australia (right).

Figure 12 (left) shows a commercial street in Rayong with downpipes currently finishing at the commercial canopy level. When it rains, water pours directly onto the road like a waterfall. Stormwater planter boxes, as shown in Figure 12 (right), are vegetated water harvesting tanks that intercept roof runoff and can be directly connected to these downpipes. With a series of planter boxes connecting to downpipes along main commercial streets, the majority of roof runoff could be detained and harvested, reducing flooding and relieving pressure on the combined sewer system.

It proposed business owners install the planter boxes, with initial financial and technical support from municipal authorities, as well as possible monetary (e.g. tax) incentives. Another incentive is that the planter boxes can be easily integrated with a range of other streetscape assets, e.g. seating, which may be desirable for cafes and markets, or advertising boards and shop signs. The design and vegetation of the planter box could be made to suit the specific commercial needs of the business owners.

Figure 13: Example of a pop-up garden.
Source: Mint Plaza, architonic.com.

Finally, street trees would be planted in regular intervals as ‘pop up’ gardens at the upstream side of each stormwater entry pit. Excessive water from the planter boxes and street runoff would flow into the pop-up gardens and be infiltrated naturally into the ground. The gardens can also be integrated with the streetscape, e.g. as part of shop fronts or motorbike parking.

Porous pavement is not proposed for stormwater infiltration in Rayong due to the possible high suspended solids load in stormwater runoff and combined sewer overflows. These factors would reduce the infiltration rate over time due to clogging within the void spaces. The measure needs frequent maintenance to remain porous.

3.1.3. Green, cool shopping hubs

This part of the strategy recommends raingardens and rainwater harvesting via water tanks which could be installed either above or below ground at markets and shopping centres in the CBD. This measure would mitigate local flooding and reduce combined sewer overflow. The harvested water could be reused for non-potable purposes (e.g. toilet flushing and surface cleansing), for aesthetic features like water fountains, or after further treatment to produce mist to improve thermal comfort in restaurants and food stalls and attract people to the area. Alternatively, the harvested water could be simply discharged to an infiltration raingarden to ensure the tank is empty for the next rain event. Planting trees and foliage in shopping spaces that are currently covered by concrete without much shade can dramatically reduce temperatures, as shown in Figure 15.

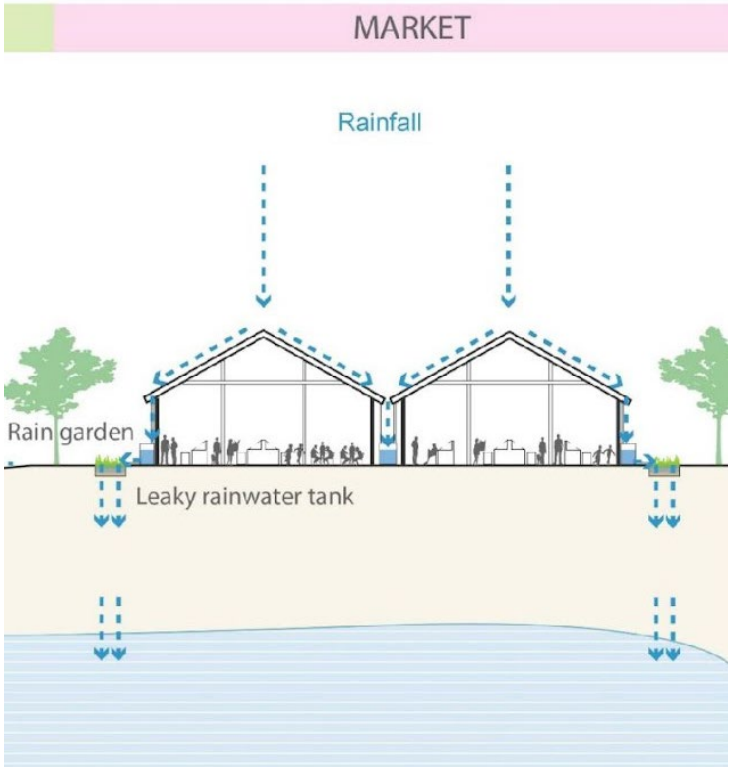


Figure 14: Cross-section of rainwater harvesting on market roofs.
Source: Project team.

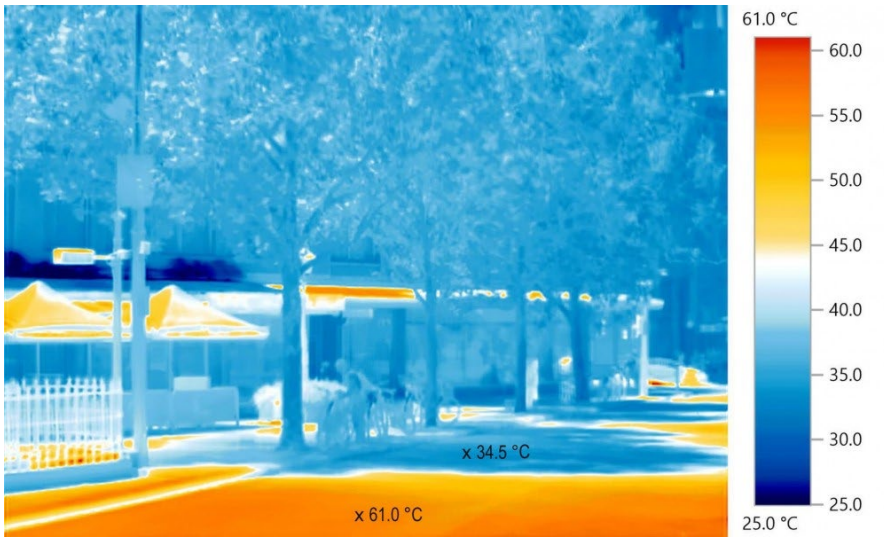


Figure 15: Thermal images taken in a January 2017 heatwave show the impact of urban heat islands in Melbourne, Australia.
Source: Victorian Department of Environment, Land, Water and Planning.[4]

Feedback from the Expert Exchange sessions raised the potential to include green roofs. Given the age and condition of many of the buildings in the study area as well as the additional structural load and cost to construct and maintain green roofs, they were not included in this strategic study but could be considered in future more detailed assessments.

3.1.4. Greening of low-lying public space

The fourth element of the strategy focuses on low-lying public space, such as car parks and transport hubs, which tend to create frequent localized flooding. Car parks also represent large areas within the dense CBD. Currently covered by concrete or asphalt, they could be easily retrofitted for greater multifunctionality, more greenery and aesthetic value.

For example, Rayong's central bus terminal has high potential for greening, with frequent flooding and uncomfortably hot temperatures. Compared with interventions on shopping streets, greening the bus terminal would also be easier to implement because it is a public asset. It could also serve as an initial demonstration to later engage the private sector to replicate measures in other privately owned spaces.

Constructing raingardens within the car park would provide canopy cover, increase natural infiltration and reduce flooding. The strategy would also reduce the amount of dust in the air which damages public health. Biofilters could be installed to treat contamination from road runoff, which would then be used to passively irrigate the gardens.

[4] DELWP (2019). *Trees for cooler and greener streetscapes: guidelines for streetscape planning and design.* Melbourne: DELWP. Retrieved from https://www.planning.vic.gov.au/__data/assets/pdf_file/0034/439297/Trees-for-Cooler-and-Greener-Streetscapes-21112019.pdf. See also CRCWSC (2014). *Impacts of water sensitive urban design solutions on human thermal comfort: green cities and microclimate*. Melbourne: CRCWSC. Retrieved from https://watersensitivecities.org.au/wp-content/uploads/2016/07/TMR_B3-1_WSUD_thermal_comfort_no2.pdf;

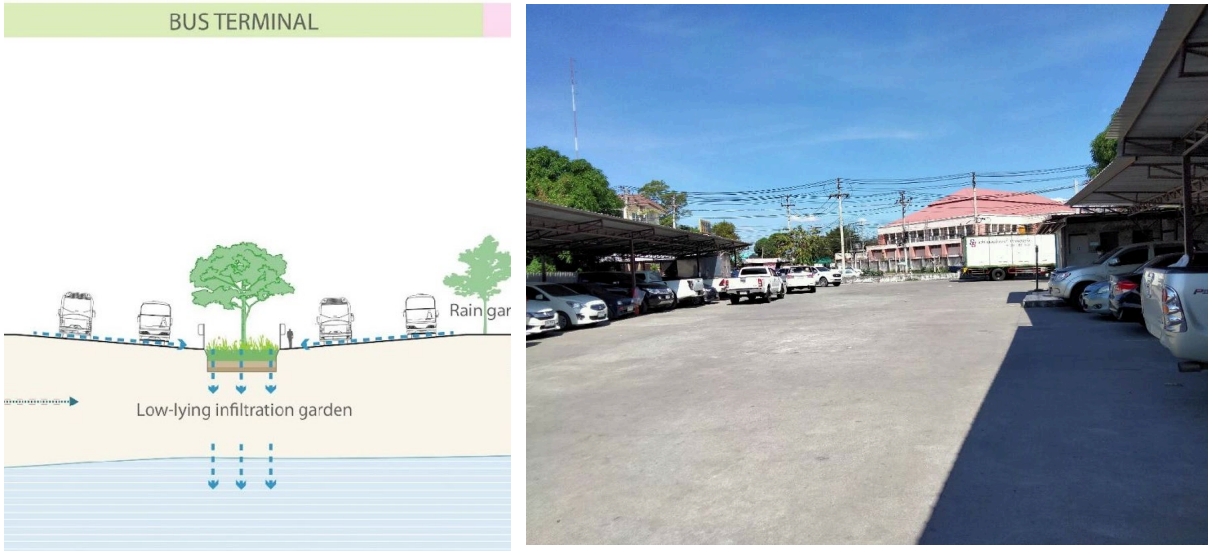


Figure 16: Cross-section showing design of a raingarden in the bus terminal (left), typical car park in Rayong's CBD (right).
Source: Project team.

3.1.5. Rayong 'Cool Lines' smart platform

The final element of the strategy proposes an innovative 'cool lines' platform for the green triangle via a digitally available map of the whole area (on a mobile app, for example). An Internet of Things based smart system that monitors urban heat would guide residents and visitors to the coolest and most shaded path in real time.

Applied at scale, green spaces also improve air quality by filtering harmful pollutants from the air. The cool lines platform could also integrate air quality index (AQI) metrics, which are especially relevant between December and March when air quality in the region tends to be poorer due to crop burning.

What is the 'Internet of Things'?

The Internet of Things, or IOT, refers to the billions of devices that are now connected to the internet, all collecting and sharing data. Connecting all these 'things' and adding sensors enables them to communicate real-time data to each other as part of 'smart' platforms.

Attractions including places to sit would be marked, e.g. the stormwater planter boxes. This system would provide a novel attraction for tourists to explore Rayong as well as give local businesses an incentive to participate in these initiatives by including them in the cool lines map. The platform could also act as an important data base for urban planners when thinking about connectivity and expanding green networks in Rayong City and beyond.

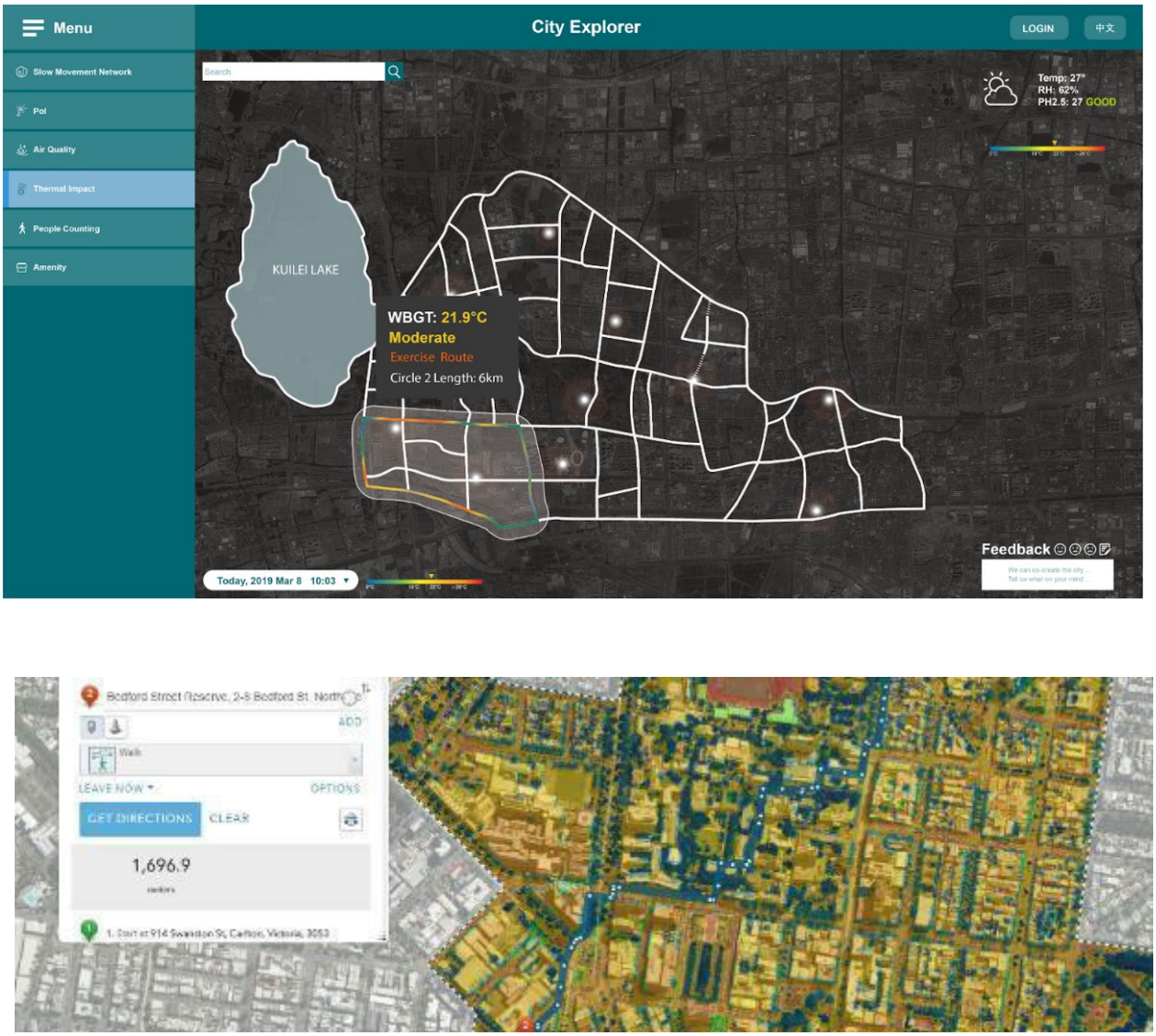


Figure 17: Cool lines platform in Australia.
Source: CRCWSC (top), spatialvision.com.au (bottom).

4. value and choose interventions

This section provides an overview of the results of the BCA. The hybrid approach was compared with the baseline, or 'do nothing' scenario. Costs were estimated in Thai Baht, and converted to USD for the economic model.

It is important to note this study is a high-level strategic assessment with data limitations. The main purpose is to ask, given the information available, whether the strategy is worth further investigation. The results can also help to prioritize measures, by examining which BCR is the strongest of the different components of the solutions, and formulate fair funding and financing arrangements based on the distribution of costs and benefits. Detailed assessment, e.g. regarding precise volume and water flow, is outside of the scope of this project and should follow as part of a pre-feasibility and pilot stage.

4.1 Overall BCR

The results show a strong overall **BCR of 9.7** over a 20-year period; i.e. for $1 invested, more than $9 will be returned in community benefit. This is equivalent to a **NPV of around USD 31 million.** This result shows NbS assets can create significant value for a broad range of stakeholder groups, including local communities, commuters, visitors, the private sector (e.g. department stores, markets, hotels) and the government – namely Rayong Municipality, the Department of Highways and the Department of Rural Roads.

Key economic terms

Net present value: Calculates today's value of a future stream of payments over the entire life cycle including costs and benefits

Benefit–cost ratio: Compares the present value of all benefits with the cost. For every dollar spent, the BCR gives you how much you will get back in benefits

Broken down, the BCR for the project organization (taken to be Rayong Municipality, Department of Highways and Department of Rural Roads) is around 1.6, with an NPV of approximately USD 600,000. Although this figure represents a lesser return on investment, the benefits still cover the costs and highlight the importance of taking a whole-of-community (rather than an organizational) perspective when considering community infrastructure. There is also potential to investigate options for sharing some of these costs across different stakeholders. More information about potential funding and financing strategies is provided in Chapter 5.

4.2 Costs summary

Figure 18 summarizes the costs associated with each strategy. Importantly these costs include both the upfront installation/construction and ongoing maintenance over the 20-year period, with the value displayed as the NPV. By far the greatest costs are greening of primary roads. This result is largely attributable to construction costs of the central depressed median which is a significant engineering task. On the other hand, interventions for the secondary roads (greening to transform them into urban canyons) includes planting and maintaining tree pits, and constructing and maintaining stormwater planter boxes which are comparatively much cheaper. The costs associated with the other elements of the strategy – rainwater harvesting tanks for shopping centres, raingardens in low-lying public space and establishment of the smart platform – are also cheap interventions over the 20-year period.

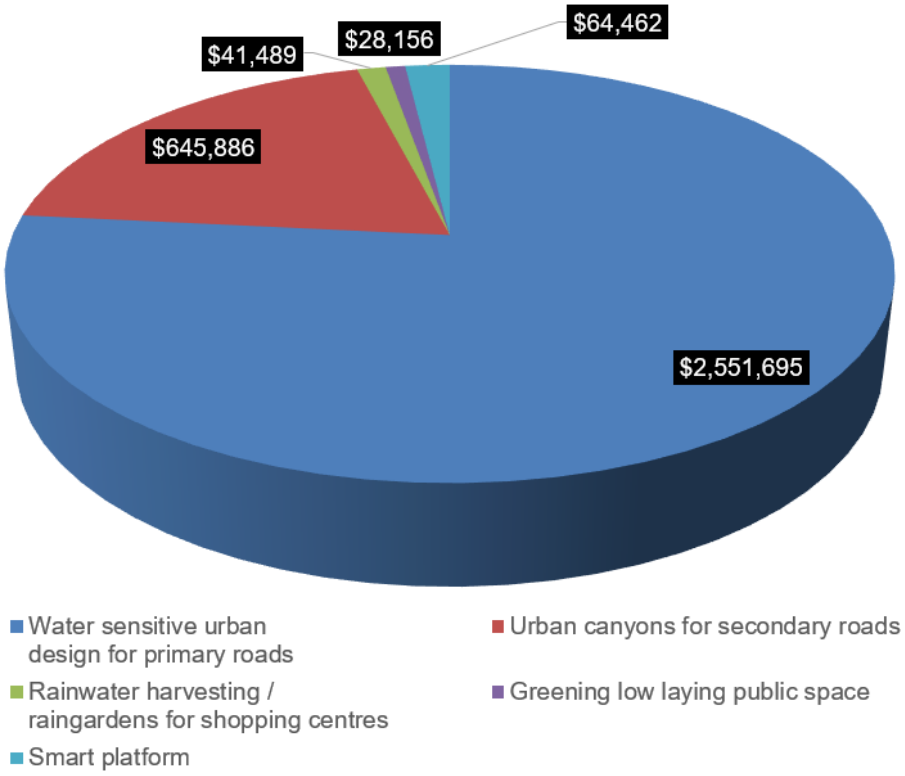


Figure 18: Costs summary.[5]
Source: Project team.

For the primary and secondary roads, a staged approach is recommended to pilot the approach (including a further BCA to compare the roads with and without the intervention), spread the costs out, and align the retrofitting with planned road renewal works which take place every 5 years. This staged approach is shown in Table 1, alongside the anticipated staging of the other parts of the strategy.

[5] These are the direct costs associated with each strategy. The total cost also includes the costs associated with raising taxes which the government then uses to finance its expenditure on the strategies.

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Primary roads															
1.1 Sukhumvit Road															
1.2 Ratchumphon Road															
1.3 Chanudom Road															
Secondary roads as urban canyons															
2.1 Phase #1															
2.2 Phase #2															
2.3 Phase #3															
2.4 Phase #4															
3. Green, cool shopping hubs															
4. Raingardens in low-lying public space															
5. 'Cool Lines' smart platform															

Table 1: Staging of interventions.
Source: Project team.

4.3 Benefits summary

A range of methods were used to estimate project benefits. These include:

- market values to estimate reductions in travel costs for commuters
- market values for avoided travel costs for commuters and avoided infrastructure upgrades (such as combined drainage/sewer pumps assumed to be needed as a result of climate change)
- value transfer using research studies from other locations identified through the INFFEWS Value Tool to estimate greening benefits to property owners through increased in property and land value
- value transfer to estimate greening benefits as a result of visitors' willingness to pay for access to enhanced green space
- value transfer to estimate the benefits of reduced coastal pollution.

Figure 19 summarizes the benefits and their value over 20 years. The most significant value, accounting for 57% of the total, is attributable to greening secondary roads via the urban canyon approach. 'Greening benefits' reflected in higher residential and commercial property values include reduced flood damage, improved amenity and improved economic activity for commercial businesses.

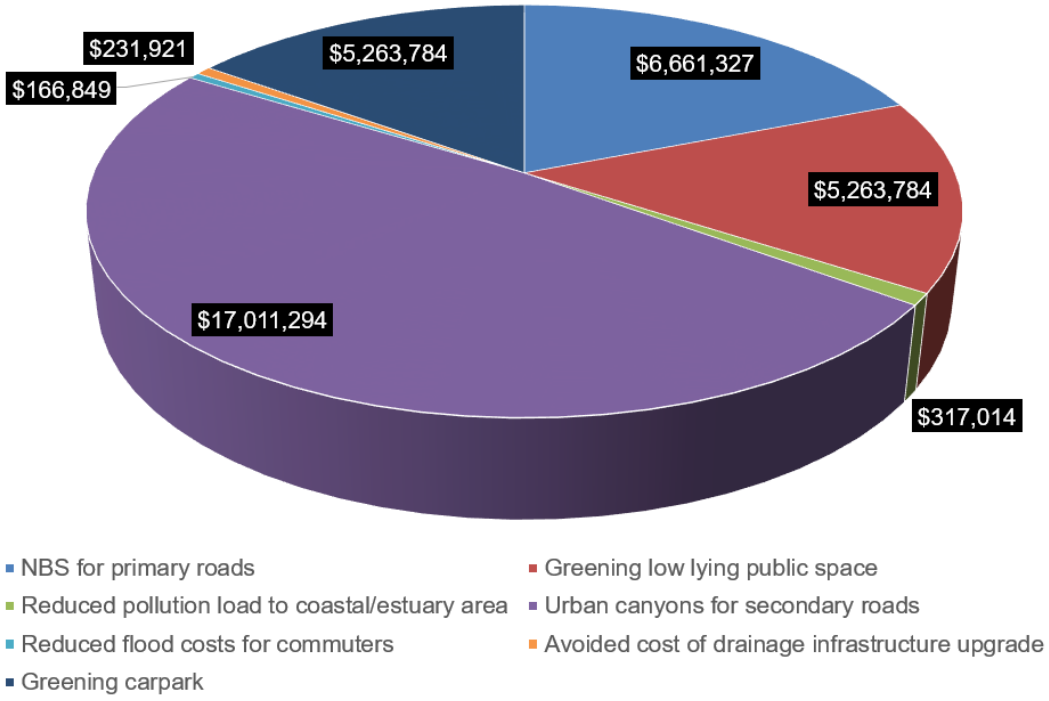


Figure 19: Benefits summary.
Source: Project team.

Figure 20 shows how benefits accrue over time. Overall, the benefits increase over time. The cumulative benefits are also mostly positive for Rayong Municipality (the project organization), although the short term impact of the first primary road upgrade in 2026 (Chanudom Road) can be clearly seen.

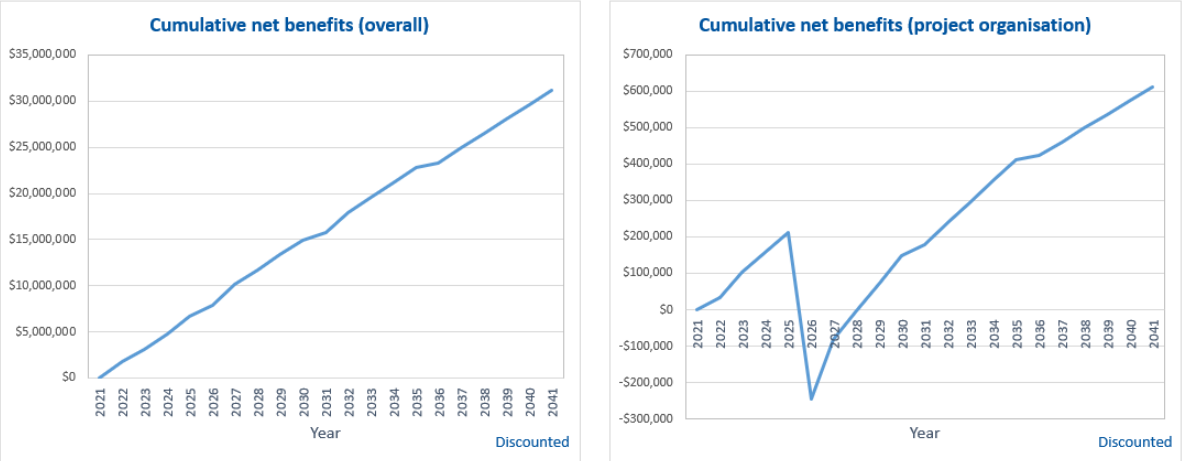


Figure 20: Cumulative net benefits over time.
Source: Project tea.

4.4 Distribution of costs and benefits

After analyzing the breakdown of costs and benefits, the next big question is determining their distribution between stakeholders; i.e. who pays and who benefits. This breakdown can be particularly relevant for sharing the costs via taxation schemes and other methods to reduce the burden on the implementing agency.

Figure 21 shows that by far the greatest benefits go to the local and broader community as well as private businesses. While it is given the public should be the target beneficiary of municipal works, this evidence might also justify an increase in general municipal taxes or rolling out a direct cost-recovery scheme such as a flat flood tax or highway tax. Additionally, the findings provide persuasive evidence for Rayong Municipality to work with the private sector to implement the strategy.

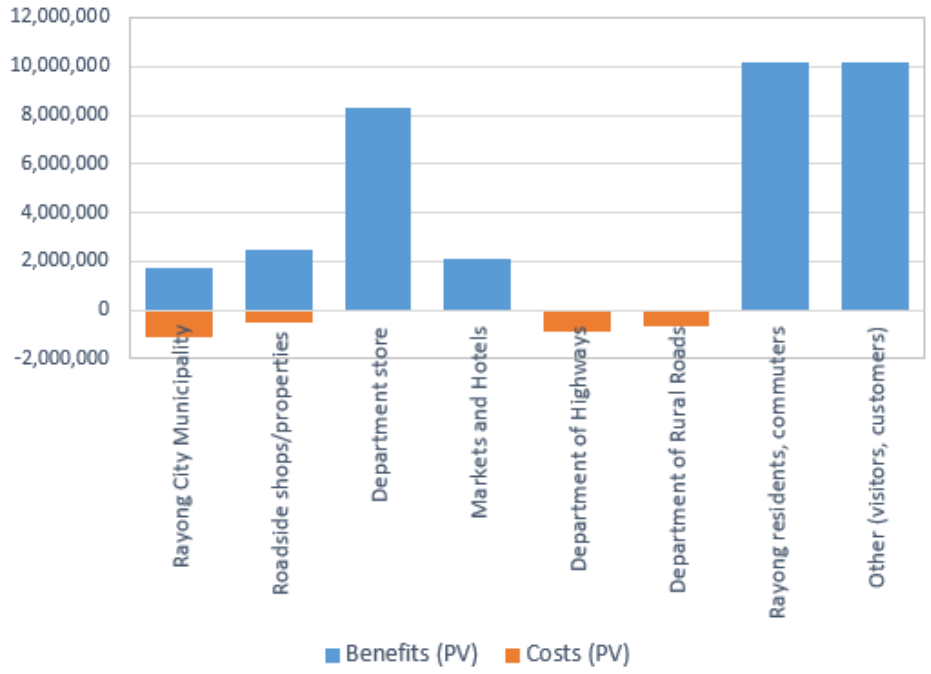


Figure 21: Distribution of costs and benefits.
Source: Project team.

4.5 Sensitivity testing

Sensitivity testing was applied to the results, with costs and benefit assumptions reduced and increased by 30% and then applied to 1,000 different simulations to test the impact of different combinations of assumptions. For all simulations, the overall benefits were greater than the costs with the lowest result being a BCR of 4.6 and a highest BCR of over 18.

For the project organization, the most likely outcome was a BCR between 1.16 and 1.57. But, there was a low probability (0.06) that a maximum BCR of 2.81 would result and a low probability (0.16) that a BCR of between 0.75 and 1.16 would result.

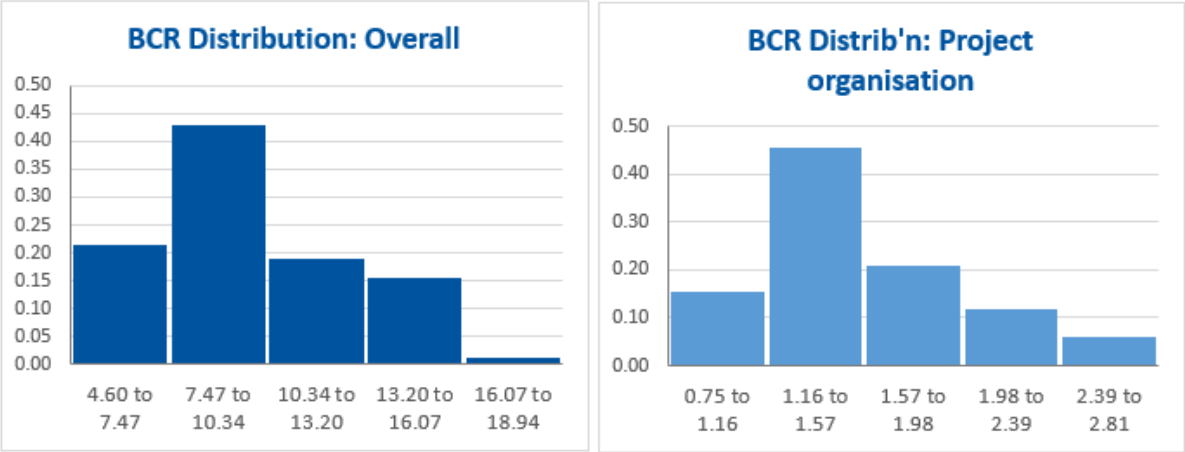
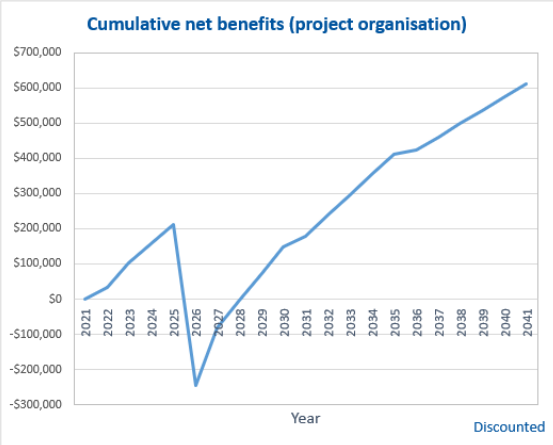


Figure 22: Results of sensitivity testing to overall BCR and project organization BCR
Source: Project team

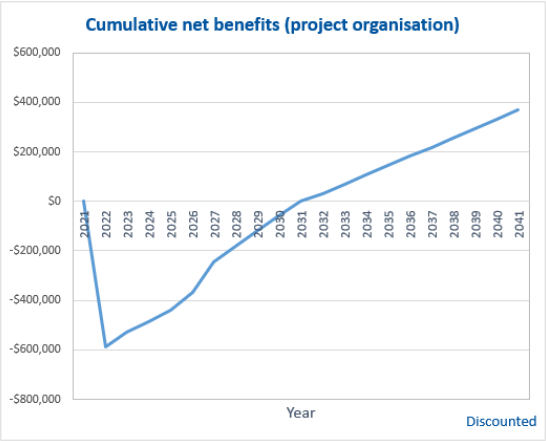
The case study assumed effective private sector engagement and capacity building will see good uptake of NbS by private property owners along the primary and secondary roads, realizing at least 80% of the possible benefits. However, even if adoption is much lower – e.g. 20% – the overall BCR remains above 5.

To reflect that people prefer money now to money later, it is standard practice to discount future benefits and costs. A discount rate of 0.04 (i.e. 4%) was used for this analysis. Sensitivity tests using discount rates of 0.02 and 0.06 did not change the conclusions of the analysis. A lower discount rate resulted in a higher BCR, reflecting that many of the proposed strategy's costs were near term while benefits accrued over time.

The impact of changing the timing of major infrastructure investment, in this case upgrading the primary roads, was also tested. The case study assumed each primary road upgrade will occur at the end of each 5-year budget cycle. If these upgrades are instead made at the start of budget cycle, then maintenance costs start earlier and infrastructure investment occurs in year 1 of the budget rather accruing interest in the bank until year 5. Figure 22 shows the benefit of deferring investment in primary roads. This approach also provides for factoring the learning from investment in smaller lower risk second roads into primary road upgrades, potentially reducing costs and risk.



Base case: cumulative benefits when investment made at end of 5-year budget cycle



Sensitivity test: Accelerating investment in primary roads to start of each budget cycle results in greater costs that more than outweigh earlier access to benefits and a longer period before cumulative benefits outweigh cumulative the costs

Figure 23: Testing whether accelerating investment delivers greater net benefits.
Source: Project team.

5. identify appropriate funding and financing mechanisms

Thailand has grown rapidly since the 1960s supported by significant infrastructure investment. Most infrastructure has been funded by government through taxation. Government also remains the largest source of finance with growth in private sector finance stagnating in recent years. However, the growing infrastructure gap driven by climate change, population growth and urbanization means previous approaches to funding and financing may not be sufficient for future needs. Sustainable and equitable investment also needs to increase to achieve future policy and national strategy goals.

This case study assumed a similar gap applies for meeting the future water, flood protection and sanitation needs in Rayong. Private investment for private and public gain is also an important element of the strategies outlined in this case study. The proposed solutions illustrate opportunities to bridge this gap noting many of the ingredients needed to fund and finance sustainable green growth are already in place but need further evolution.

5.1 Enabling policy and strategy

Thailand's vision for national development is articulated in the Twelfth National Economic and Social Development Plan (12th NESDP). This 12th NESDP was recently complemented by the 20-Year National Strategy which outlines a long term vision for sustainable development and was introduced to drive implementation of the 5 year NESDPs. The 12th NESDP focuses on:

- reducing poverty and inequality
- improving the competitiveness of the local economy including restructuring towards a digital economy
- green growth including an increase of total forested areas to 40% and a net reduction in GHG emissions to 7%.

The 12th NESDP is also supported by:[6]

- **Thailand 4.0** presents a new economic model for the country and cuts across the 12th NESDP and 20-year National Strategy. Its key contents are economic prosperity driven by innovation and technology, social wellbeing, and environmental protection with a low carbon society and an economic system capable of adjusting to climate change.
- **National Climate Adaptation Plan (NAP) 2019** is built on the 6 priority sectors identified in the Climate Change Master Plan (2015–2050): water management, public health, human settlements and security, tourism, natural resources management, agriculture and food security.

The solutions set out in this case study strongly align with these national strategies, particularly because they promote climate resilience, innovation and increased urban liveability through a green, cool and flood-resilient CBD. The Rayong case study strategies could provide a

[6] UNDP. *Development Finance Assessment Snapshot – Thailand. 2021.* Retrieved from https://www.th.undp.org/content/thailand/en/home/library/development-finance-assessment-snapshot---thailand-.html

valuable pilot initiative with clear links to national goals and potential for national support in testing and scaling up application of NbS in growing regional areas. This could be further aided by integrating IUFM principles and NbS into budgeting processes and resources such as the guidelines for Climate Change Budgeting Analysis (CCBA).[7] Achieving the vision will require mobilizing the right scale and mix of funding and financing, from both public and private, and domestic and international sources.

OECD 2021 noted:

Green growth and green investment will be key to meeting the vision for Thailand 4.0, especially in the context of COVID-19 recovery. A green growth pathway allows Thailand to grow and develop while ensuring that natural assets continue to provide resources and environmental services for future generations, and that growth pathways remain resilient to global shocks such as climate change or future pandemics. A key step in pursuing green growth is to catalyze investment and innovation in environmentally sound technologies and infrastructure which helps to sustain growth, gives rise to new economic opportunities and promotes green jobs.[8]

As discussed in Chapter 1, a key policy guiding Rayong's economic development is the EECDP, approved by the Thai legislative Assembly in 2018. Under this plan, the 3 eastern provinces of Chachoengsao, Chonburi and Rayong will be the focus of accelerated economic growth in the transport and industrial sectors.

Another important policy is the ongoing Rayong Provincial Development Plan (2018–2022). The plan was based on 4 principles:

1. **Balanced development** between industrial, agricultural, tourism and commercial sectors
2. **The 'Sufficiency Economy Philosophy**' which espouses a balanced and moderate development pathway to ensure Thailand is not adversely affected by volatility of global markets and financial systems
3. Infrastructure will support economic growth with a focus on **innovation** in the industrial sector
4. Emphasis on **health, welfare and environmental sustainability.**

The plan's development goals fit under 5 primary categories: 1) agriculture, 2) tourism and services, 3) industry, 4) natural resources and the environment, and 5) social and public sector development.

The strategies outlined in this case study can contribute to all 5 primary categories. In particular, under Category 4 (natural resources and the environment) relevant goals include:

- Increase green areas in the province as well as conserve and rehabilitate marine and coastal resources
- Manage water resources to ensure water supply is sufficient and of adequate standard

[7] UNDP (2016). *Climate Change Benefit Analysis CCBA Guidelines*. Retrieved from https://www.th.undp.org/content/thailand/en/home/library/environment_energy/climate_change_benefit_analysis_ccba_guidelines.html

[8] OECD (2021). *OECD investment policy reviews: Thailand*. Paris: OECD. Retrieved from https://www.oecd-ilibrary.org/sites/6091762f-en/index.html?itemId=/content/component/6091762f-en

- Manage solid and hazardous waste, including ensuring proper waste treatment/disposal, including through recycling and community garbage collection and disposal
- Reduce greenhouse gas emissions and adapt to impacts of climate change
- Monitor and evaluate natural resource usage across all sectors.

The total investment under the plan is approximately 18.2 billion Baht (555 million USD). Of this, 2,033 is allocated to road renovation, 1,838 to road infrastructure upgrading and 2,189 to the water sector, which includes drainage projects, water distribution and storage and water pumping stations across the province.[9]

The plan will be revised for the next 5-year development planning period (2022–2026), presenting an opportune moment to bring in new approaches for sustainability. A strong business case clearly aligned to government policy objectives can also increase the likelihood of public funding support. Further, NbS have the potential to provide co-benefits, therefore mainstreaming them into the next planning period may invite a more integrated approach to budgeting.

5.2 Balancing centralized and decentralized solutions

Improving access to financing requires a robust approach to project proposal development and evaluation, acknowledging all relevant costs over the project lifecycle, considering broader value adding opportunities, and valuing both economies of *scale* and economies of *scope*. As illustrated by the case study, the IUFM approach can balance large infrastructure assets and smaller scale decentralized solutions as well as green, gray and non-structural solutions that reduce the overall cost to be financed. The Rayong case study highlights the additional value of NbS and decentralized initiatives (e.g. the urban canyons on secondary roads) in supporting large investment (interventions along primary roads).

5.3 Taxation and fiscal budgets

The BCA process in this case study highlighted the significant benefits that flow to private business and communities across Rayong City. This evidence may justify adopting a beneficiary pays approach with funding provided via a small increase in general rates and taxes or the roll out of a transparent targeted measure such as a flat flood tax or highway tax.

5.4 Leveraging private investment and social capital

Public finance and funding will continue to play an important role in promoting green growth and IUFM. The IUFM process also seeks to help bridge the public infrastructure gap by identifying and monetizing additional revenue streams (e.g. stormwater capture and sale) reducing the need for public funding and increasing financability and scalability.

In Expert Exchange sessions, Rayong Municipality emphasized the importance of engaging the private sector. A model from a related sector that is already being applied in Rayong is the

[9] Rayong Provincial Development Plan, 2018.

'PPP Plastic' initiative which targets private and community action to better manage plastic waste.[10]

Speaking at an event marking the first anniversary of the project in Rayong, Governor Surasak said:

> *Rayong is playing a pivotal role in the economic, industrial, tourism and agricultural development of the country. Therefore, the province is aware of the importance of effectively managing its sustainable growth by emphasizing and addressing solid waste and environmental concerns through the cooperation and strong commitment of all sectors. To this end, the 'PPP Plastic' project, a partnership involving the public and private sectors, and civil society to sustainably address plastic waste in the pilot areas of Rayong province, officially got underway with the signing of a MoU on December 18, 2018. The project, in line with the concept of the Circular Economy, has been ongoing for over one year to minimize the amount of waste while promoting the efficient use of resources. It is further concentrating on developing the integrated management of all sectors, increasing knowledge and public understanding such as behavioral change towards waste disposal, reducing and sorting waste, development of a waste segregation and recycling system, and reducing the use of single-use plastics.*[11]

However, feedback from Expert Exchange sessions raised concerns that the time and transaction costs associated with formal arrangements like PPPs may be challenging to implement. Less formal or simpler arrangements such as Memoranda of Understanding (MoUs), joint ventures, incentive programs, accreditation schemes or joint branding of initiatives could be a more practical way to engage businesses as part of their Corporate Social Responsibility (CSR) initiatives.

Engagement linked with a clear and inspiring vision for Rayong City (such as the initiative for 'green and cool shopping hubs') can also encourage local community engagement and private action.

> *There is a local belief that we need to plant a family tree. This could be a good incentive for communities and the private sector to be involved. In Rayong we even have a specific type of famous tree which could be used as a symbol, and the Ministry of Culture could be involved in its promotion.*
>
> *Mr. Pipat Ruanggam, Bangkok Department of Water Resources* [12]

Box 1 provides an example from Australia of an effective private and community sector engagement and investment for improved stormwater management.

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[10] GC (2020). *Thailand public–private partnership for plastic waste management*. Retrieved from https://gccircularliving.pttgcgroup.com/en/collaborative-projects/321/thailand-public-private-partnership-for-plastic-and-waste-management

[11] GC (2019). *Rayong announces its one-year waste management performance in developing a circular economic model*. Retrieved from https://gccircularliving.pttgcgroup.com/en/news/better-chemistry/421

[12] 2nd Knowledge Exchange for Executives and Experts – Thailand, Identifying IUFM solutions and benefits, 22–23 March 2021.

Box 1: Harnessing private action for public benefit

Melbourne Water's 10,000 Raingardens Program demonstrates that is it possible to engage the community and encourage them to take actions that have public benefits.

The program encouraged private landowners to establish raingardens on their own properties. These specially prepared gardens are designed to receive, slow down and filter rain runoff from roofs or impervious surfaces such as driveways or paving. This stormwater runoff can significantly affect the health of our rivers and creeks, carrying harmful pollutants such as litter, chemicals, animal droppings and oil. Raingardens help by reducing the quantity and improving the quality of stormwater runoff entering local waterways.

Figure 24: 10,000 raingardens website

Source: Melbourne Water

The program promoted this simple and effective form of stormwater treatment by raising people's awareness of:

- How stormwater fits into the water cycle
- How good management of stormwater contributes to healthy waterways, and
- what can easily be done at home to manage stormwater.

Melbourne Water did not provide financial incentives for landowners to build raingardens. Rather, the focus was on encouragement through education. Integral to the program's success was addressing common barriers to installing raingardens:

- Limited awareness that stormwater is a problem – Melbourne Water established a website and prepared brochures explaining how stormwater runoff affects waterways and how raingardens can help.
- Limited community understanding of raingardens – Melbourne Water provided technical support for landowners about how to build raingardens, via brochures and the website. It also worked with councils on demonstration projects to create raingardens in public places such as streets, parks and schools.
- Lack of industry knowledge at the residential scale – Melbourne Water also provided technical training for plumbers and landscapers.

The number – 10,000 – was intended to raise interest, generate discussion and spur grass roots community interest. Competitions for hardware vouchers successfully encouraged landowners to register their raingarden. The program, which started in 2008, achieved its target of 10,000 raingardens across Melbourne in 2016. The program has now been incorporated into Melbourne Water's stormwater program.

Sources: Milenkovic, K., Potter, M. & Morison, P. (2012). Community engagement: the story of the 10,000 Raingardens Program. Paper presented at the Stormwater '12 Conference, 15–19 October, Melbourne; Melbourne Water (2016). Melbourne's Water Future Green Paper, Melbourne Water's Submission. Melbourne.

5.5 Incentivization schemes

Tax incentives were also proposed as a modality with strong potential for increasing uptake of NbS and/or reducing flooding and environmental degradation. For example, private groups wanting to construct a car park may be offered incentives when applying a certain construction material or technique (e.g. using pervious pavements or including raingardens). These sorts of incentives should be accompanied by capacity building and education to ensure green assets are built and maintained to achieve promised functionality and benefits.

Private sector innovation and investment could be encouraged via incentives such as those available from Thailand's Board of Investment (BOI). For example, the BOI currently lists renewable energy generation and waste treatment among eligible activities under its BCG (Bioeconomy, Circular, Green economy) concept.[13] Eligible activities could be extended to NbS that address urban flooding, improve health outcomes, enhance the environments, promote tourism and mitigate heat.

Another incentivization scheme that already operates in Thailand is the floor area ratio (FAR) bonus, which restricts the FAR for developments. Currently, the maximum FAR is 10:1 but bonuses up to 20% are available if certain features are included in the building design including low-income housing, green space, stormwater storage and participation in the Thai Green Build Institute certification program. Greater inclusion of NbS including rainwater harvesting, stormwater planter boxes and raingardens together with training and capacity building programs could aid uptake by developers.

The FAR Bonus provides a positive incentive. A 'polluter pays' approach could also be applied to stormwater discharges. In Rayong, property owners with large impervious areas (e.g. shopping centres with large car parks) who invest in NbS to manage flooding could receive exemptions or discounts. Charges/incentives based on impervious area have been introduced in some locations, such as DC Water's Clean Rivers Impervious Area Charge (CRIAC).[14]

An impervious area charge could be a simple fixed charge for different categories of properties (e.g. residential, commercial and industrial) where properties have similar areas and imperviousness, or a more sophisticated model based on good data on individual property stormwater discharges. In both cases, discounts for private investment to increase perviousness could be offered. Further, both require good information on imperviousness, piloting and appropriate transition arrangements to avoid unintended consequences and unfair impacts.

[13] Thailand Board of Investment (2021). *BOI Go Green*. Retrieved from https://www.boi.go.th/upload/content/BOIBCGEN2021_60827220decab.pdf

[14] DC Water (2017). *Impervious water charge*. Retrieved from https://www.dcwater.com/impervious-area-charge. See also City of Raleigh (2021). *Stormwater fee frequently asked questions*. Retrieved from https://raleighnc.gov/SupportPages/stormwater-fee-frequently-asked-questions

The *Planning Guidelines of Rainwater Utilization System in Shenzhen* in China illustrates an alternative or additional measure requiring the retention and use of all rainwater in residential areas. Residential areas that do not invest in facilities to use rainwater or fail to meet targets for usage will be charged a 'rainwater discharge fee'. Residential areas that exceed the requirement may be granted rainwater credits which can be sold to residential areas that fail to fully meet the requirements.

Such regulations can promote NbS by enabling property owners or developers to meet a portion of their obligations by buying volume-based 'credits' generated through blue and green investments in offsite NbS. To succeed, such initiatives require a strong regulatory foundation, as well as sufficient local development to drive demand for credits informed by guidelines developed according to local conditions, clearly defined program boundaries and an independent oversight body. Information requirements are also extensive. A more appropriate solution for Rayong may be introducing a small fixed charge, which may be expanded to a credits/trading model in the future. Implementation should consider income levels/property prices to ensure charges are not directed at low-income communities who may struggle to pay.

THE FIRST STORMWATER PURCHASE AGREEMENT IN CHINA

On September 25 2020, Changsha Gaoxin District Park Company and the Hunan Yuchuang Environmental Protection Company signed the first stormwater purchase agreement in China at the Hunan Province Green Development Exhibition Sponge City Forum.

According to the agreement, the Changsha Gaoxin District Park Company will purchase stormwater from the Hunan Yuchuang Environmental Protection Company at a 20 percent of the piped water price for landscaping and cleaning purposes. The Hunan Yuchuang Environmental Protection Company has worked on rainwater retention and utilization from 2014 and has utilized 0.5 million cubic meters of rainwater, which amounts to 2 percent of the total rainwater during the last 6 years, which means there is still large potential for rainwater utilization.

Source: Changsha Evening News 2020

Figure 25: The First Stormwater Purchase Agreement in China.
Source: Chansha Evening News 2020

5.5 Taking advantage of a growing green finance system

Greening Rayong's CBD is an important demonstration project. Financing could reinforce messaging around green growth. For example, the greening strategies included in this case study could be aggregated with other sustainability initiatives from other locations (e.g. NbS based waste treatment and renewable energy generation) as part of a diversified green bond issue. This approach provides financiers and investors an opportunity for ethical investment with aggregation leading to lower total transactions costs and lower risk through diversification.

6. Recommendations and next steps

The following high-level recommendations and next steps have emerged from the case study development. As a basis for all the points below, a multi-sectoral approach with cooperation across public agencies representing the implementers at provincial level (Rayong Municipality, Department of Highways, Department or Roads), national policy makers (ONEP), planners and strategy makers (NESDC, ONWR), together with private and community groups will be needed to make the vision a reality.

- **Further refinement of benefits and costs.** The strategic assessment provided by this case study illustrates the significant merits of a hybrid approach. Further refining the key inputs is recommended. This should include a deeper understanding of peak and dry weather stormwater and wastewater pathways from source to destination. Local revealed or stated preference studies of key benefits could also be considered. Further developing costs and benefits would not only increase confidence in the proposed approach but also provide relevant local research to inform scaling hybrid approaches to other parts of Thailand.

- **Advantages of demonstration and a phased approach.** Piloting can be a key part of establishing proof-of-concept for new approaches, as well as building local capacity and attracting private investment. However, for nature-based and hybrid measures, it can be difficult to deliver anticipated benefits with small, standalone projects. Often, as demonstrated in this case study, benefits emerge with implementation at scale.

  This case study demonstrated how a phased approach could support rolling out NbS throughout Rayong's CBD – particularly for retrofitting primary roads. The strategy starts with one primary road as a pilot, then retrofitting additional roads at 5-year intervals. Phasing helps manage risk, spreads out costs and capitalizes on regular planned maintenance works on the roads to avoid excess costs and minimize disruption. It also enables trust in the measures to build and learning from the pilot phases to inform future development. For critical roads such as Sukhumvit Road for which downtime is not an option, a suite of successful pilots on primary, but less critical roads could constitute a strong evidence base for national building code reform.

  Developing and maintaining the interventions should also include appropriate monitoring and analysis of the performance of NbS elements to support local adaption and scaling their application. This could also include community engagement and citizen science opportunities.

- **Delaying infrastructure upgrades will lead to greater costs in the long term.** Although upfront infrastructure costs can be significant, costs of delay will be much greater over time. Currently, a key contributor to flooding is the city's outdated and complex drainage system which frequently blocks. Rayong is envisaged to be the EEC's urban core. If the city expands under a business-as-usual approach without major upgrades, future damage costs from flooding and other climate-related hazards will be significant.

  As well as direct flood mitigation, this case study demonstrated hybrid solutions can reduce upfront and ongoing costs. For example, currently, stormwater runoff travels through the city before it is pumped to the sea in the tidal gate. As the city expands, additional or larger pumps will be needed. However, the approach proposed in this case study can avoid this cost by allowing water to infiltrate naturally, or by collecting

and reusing it. Further study can be done to estimate the costs avoided via different urban planning and water resources management scenarios.

During the Expert Exchange sessions, participants raised the importance of sourcing local materials for sustainability and implementing simple designs together with appropriate incentives, capacity building and technical support . This second point is particularly important in Rayong given many of the private landowners are small businesses who may have limited ability to invest in NbS. Small scale interventions distributed throughout the streetscapes, market places and open spaces are more appropriate in this context.

Rayong Province already experiences water scarcity and competition over water resources due to industrial development This situation will worsen in the future with climate change projections indicating more severe dry periods during the dry season. Implementing measures to make Rayong more water sensitive through a phased plan will help manage growth sustainably.

- **Transition to separated systems.** Aligning with the previous recommendation, another key next step should be separating sewerage and wastewater systems. Outdated combined systems which are still widespread in Thailand seriously limit sustainable urban development. As a priority, Rayong municipal authorities should commence the transition to separated stormwater and wastewater systems, both retrofitting existing systems and fitting separated systems in new developments. Although high upfront costs are involved and the transition may need to be rolled out over an extended period, the cost of delay is even greater. Separating stormwater from wastewater will reduce pressure on pump operation and reduce combined sewer overflows. A pressure sewer system is recommended for Rayong's flat terrain.
- **Clear identification of roles and responsibilities for maintenance.** A further key point in Thailand that also emerged during Expert Exchange sessions was around responsibilities for maintenance**.** In Rayong, the hybrid strategy may require the cooperation and consent of many private individuals.

  Construction and maintenance requirements are made more complex because the strategy proposes public agencies construct some elements on public land (e.g. the interventions on primary roads) and others on private land (e.g. the urban canyons and rainwater harvesting tanks on shopping streets and shopping centres).

  Broad stakeholder engagement and clear definition of roles and responsibilities should be a key part of any pre-feasibility and piloting phase. Engagement should also be opened to other municipalities at the provincial level to share learning and for collaboration – particularly due to the strategy's focus on primary roads that form regional and national networks.
- **Integration of NbS with budgeting guidelines and incentive programs.** Thailand has may examples of policy regulation and strategies addressing climate change, green growth and sustainable development. This case study identified opportunities to include IUFM principles and NbS to further enhance these important initiatives at:
  - National budget level (e.g. integrating IUFM principles in guidelines for climate change budgeting analysis (CCBA))
  - Regional planning level (e.g. augmenting the FAR Bonus scheme)
  - Industry development level (e.g. Board of Investment incentive eligibility)
  - Municipal funding level (e.g. considering beneficiary pays increases to municipal taxes or introducing polluter pays impervious area charges).