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

TOWARDS A CIRCULAR ISLAND ECONOMY – DUONG DONG FRESHWATER WILDLIFE CONSERVATION PARK, PHU QUOC

CASE STUDY REPORT

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

Prepared by: **CRCWSC and ICEM**

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Executive summary

The vision of this case study is enhanced flood management via a multifunctional freshwater wildlife conservation park. It presents a unique draw for tourists and a valuable recreational space for residents of Duong Dong ward, and leads the way in demonstrating circular economy and sustainability principles in Vietnam.

As a closed island system, and leading national and international tourism destination, Phu Quoc faces both unique opportunities and challenges. However, if mounting problems with flooding, water supply, water demand, pollution and waste management cannot be urgently addressed, its communities as well as its tourism industry will suffer.

Flood risk in Duong Dong ward is high, so doing nothing is no longer an option. This case study considered the costs and benefits of both a conventional solution for flood mitigation (dredging and widening Duong Dong River which flows all the way through downstream Phu Quoc City), and a hybrid approach (developing a multifunctional freshwater wildlife conservation park linked with a combined waste recycling facility).

This strategic assessment suggests both options will add value to the community but in very different ways. Both options return around USD 3 of community value for every dollar invested. The conventional approach provides a slightly stronger overall benefit–cost ratio (BCR) of 3.3 with a net present value (NPV) of USD 139 million, but at a much greater cost. The hybrid approach has a BCR of 2.8 and an NPV of USD 65 million.

Results illustrate the choice between scale and scope that is often associated with comparing conventional and hybrid solutions. While the conventional approach would offer significant benefits in terms of flood mitigation, the hybrid solution still offers a strong level of flood protection compared with the baseline. As well as exceeding the minimum flood protection design requirements, the hybrid solution offers a range of additional co-benefits, including cost savings from waste disposal and significant amenity, recreational and biodiversity benefits to park residents, residents of the wider Phu Quoc City and tourists. The hybrid solution also includes more options for funding and has a lower financing requirement. This lower cost may enable inclusion of additional retreat adapt or defend flood mitigation measures and/or free public funds for spending on other investment priorities. The choice between options will ultimately be for policy makers to decide how to best allocate scarce resources. This initial strategic assessment also highlights the value of further investigating and applying the Integrated Urban Flood Management (IUFM) approach.

The hybrid solution also attempted to go beyond water management to show how circular economy thinking can apply to both water and waste management and present integrated solutions. Across the whole island, Phu Quoc should look at how to minimize the import of resources and more efficiently and sustainably use its existing resources. The goal should be a self-sustaining island that promotes inclusive development, safeguarding the environment and the needs of local communities as well as growth of the tourism sector. Circular economy approaches including hybrid solutions can present ‘win-win’ solutions to balance competing needs and create opportunities for public–private partnerships and long term community value.

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

AHD	Australian height datum
ARI	average recurrence interval
AWP	Australian Water Partnership
BCA	benefit–cost analysis
BCR	benefit–cost ratio
COD	chemical oxygen demand
CPC	City People's Committee
CRCWSC	Cooperative Research Centre for Water Sensitive Cities
DFAT	Australian Government Department of Foreign Affairs and Trade
DOC	Department of Construction
GEDSI	gender equality disability and social inclusion
GHG	greenhouse gas
GIS	geographic information system
HCMC	Ho Chi Minh City
HEC-HMS	Hydrologic Engineering Center-Hydrologic Monitoring System
HEC-RAS	Hydrologic Engineering Center-River Analysis System
ICEM	International Centre for Environmental Management
IFC	International Finance Corporation
INFFEWS	Investment Framework for Economics of Water Sensitive cities
IOT	Internet of Things
IUFM	Integrated Urban Flood Management
IWRM	Integrated Water Resources Management
IWRMA	Integrated Water Resources Management Assessment
LEED	Leadership in Energy and Environmental Design
MBR	membrane bioreactor
NbS	nature-based solutions
NGO	non-government organization
NPV	net present value
ODA	Official Development Assistance
OECD	Organisation for Economic Cooperation and Development
PPC	Provincial People's Committee
PPP	public–private partnership
RCP	Representative Concentration Pathway
SWMP	Sustainable Water Management Project
WSS	water supply system
WWTP	wastewater treatment plant

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 trialled the innovative Investment Framework For Economics of Water Sensitive cities (INFFEWS) which comprises a Benefit–Cost Analysis (BCA) Tool and a Value Tool that adjusts existing non-market values for application in 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 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.

This case study is associated with a parallel World Bank-funded, ICEM-implemented study *Integrated Water Resources Management Assessment – Phu Quoc Sustainable Water Management Project*. That study developed a knowledge base on water resources, water services and institutional capacity needs for water management on the island. Both projects feed into the World Bank's broader investment program with the Kien Giang Provincial People's Committee (PPC) on the island – the *Sustainable Water Management Project* to address urgent water infrastructure gaps. That investment program includes a wastewater treatment plant (WWTP) in Duong Dong with a capacity of 10,000 m^3/day, about 170.5 km of collection sewers and about 8,000 household connections. Figure 1 illustrates the connections between these initiatives.

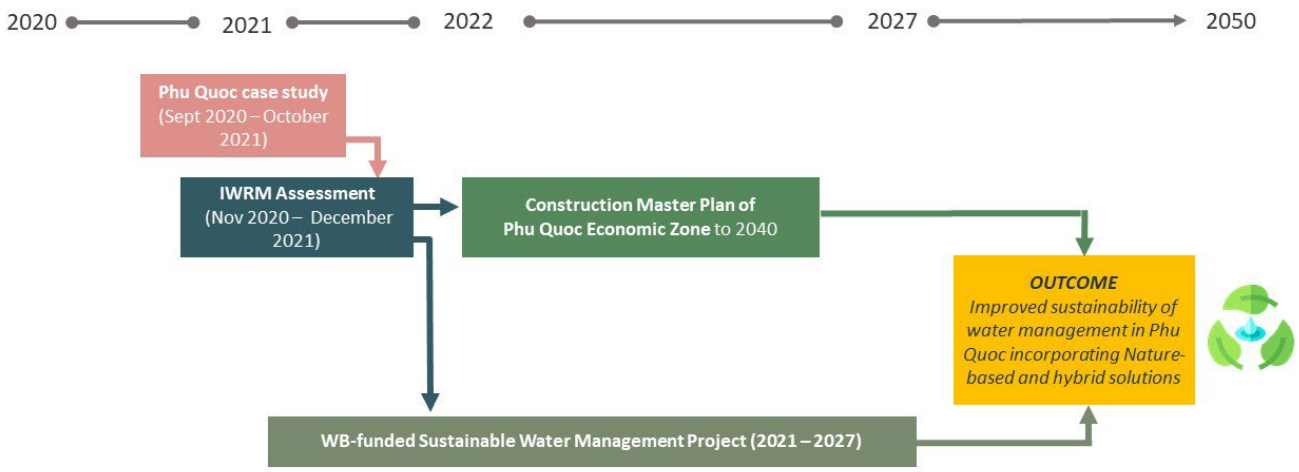


Figure 1: Connections between this case study and other projects, programmes and plans in Phu Quoc.

Source: Project team.

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.

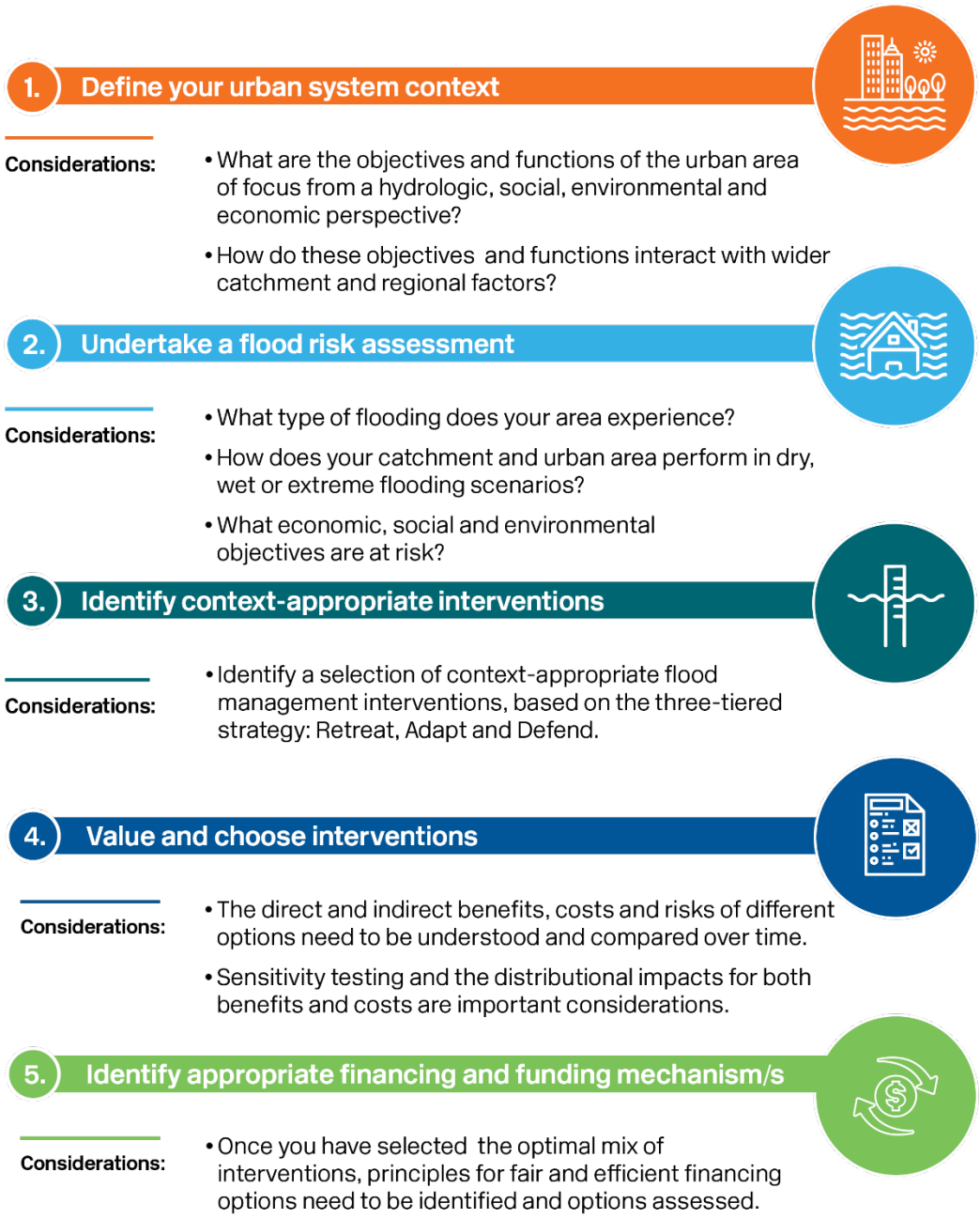


Figure 2: IUFM process.
Source: Project team.

The case study began with an initial site visit and consultations with government agencies. The flood risk assessment stage was informed by the *Integrated Water Resources Management Assessment – Phu Quoc Sustainable Water Management Project* for which island-wide climate change assessments and flood modelling were undertaken.

This case study compares the planned conventional response to flooding – dredging and widening the Duong Dong River – with a potential hybrid solution of a multifunctional wetland park that both mitigates flooding and delivers a range of other co-benefits. The hybrid solution was developed based on national and international best practice and the expertise of the project team. The appropriateness of the proposed solution was tested with national stakeholders during the second training module delivered 30–31 March 2021.

This case study presents 2 separate BCAs relative to a 'do nothing' scenario: one for the conventional response and one for the hybrid solution. This approach involved compiling cost and benefit estimates for the components of each response. Costs were taken mainly from national cost norms and official statistics. This data was supplemented with data from other countries in Asia where there were gaps. A key resource was a previous study conducted by the CRCWSC with support from the World Bank on valuing the benefits of NbS for IUFM in Kunshan, China.[1]

Benefits were calculated using a mix of official statistics and supplemented by the INFFEWS Value Tool allows which allows practitioners to adjust and transfer benefit valuations from relevant research studies. For example, benefits for flood protection were estimated using value transfer from a study on willingness to pay for flood reduction in Nghe An, in Vietnam's Central Region.[2] The value was then adjusted using official house prices in Phu Quoc compared with Nghe An, and for relatively lower flood intensity in Phu Quoc compared with Nghe An. A final value emerged by multiplying the willingness to pay per household in the study with the estimated number of flood-affected people within a 500 m radius of the Duong Dong River. The full cost and benefit assumptions can be found in the Annexes.

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%.

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

[1] Wishart, M., Wong, T., Furmage, B., Liao, X., Pannell, D. and Wang, J. (2021). *The Gray, Green, Blue Continuum: Valuing the benefits of nature-based solutions*. Washington DC: World Bank.
[2] Reynaud, A. and Nguyen, M. H. (2016). 'Valuing flood risk reductions'. *Environmental Modeling and Assessment*, *21*(5), 603–617.

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 how examples from Australia could be applied to Phu Quoc.

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.

At the beginning of the process, the case study methodology included extensive stakeholder engagement, which helped to narrow down the selection of potential case study sites in line with government priorities. Aligning with the steps in the IUFM process, a series of capacity building and consultation workshops were organized throughout the project that brought together key stakeholders and experts to provide feedback and discuss broader implications including opportunities and challenges for scaling up. To ensure continuity of learning outcomes and to support the development of a community of practice, the same participants were invited to each event.

Figure 3 shows the agencies that were involved in the case study at national, provincial and ward level.

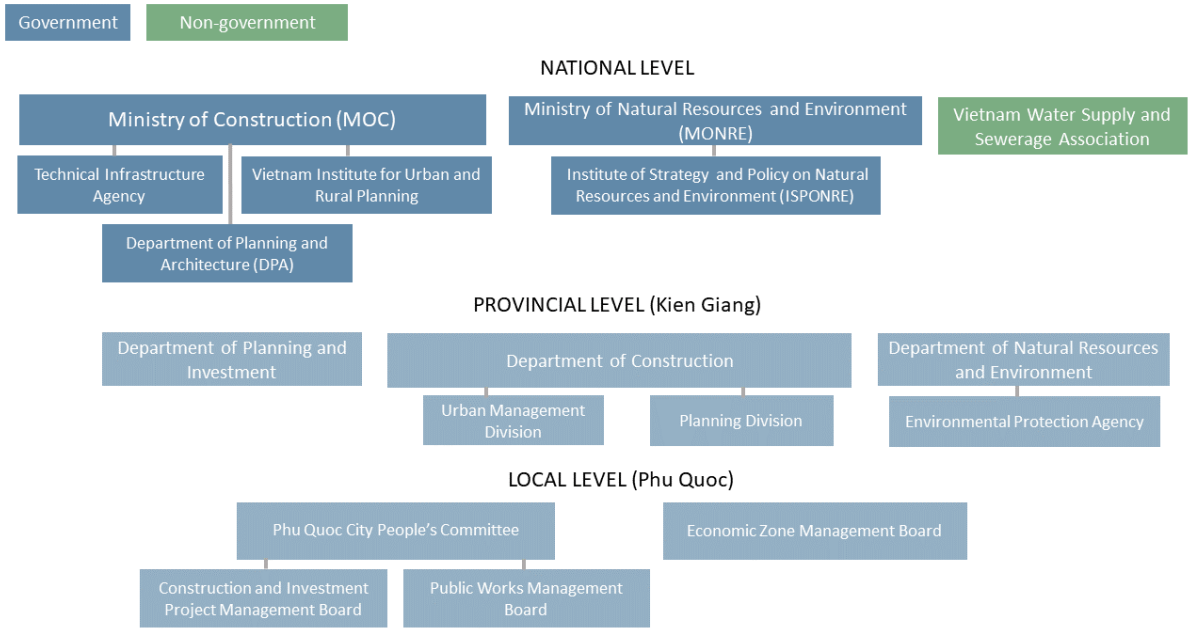


Figure 3: National stakeholder involvement in the Phu Quoc case study.
Source: Project team.

Three workshops were held:

- **1. Foundational training for national stakeholders (21–22 January 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 Vietnam. The session also introduced the project's four case study locations (two in Vietnam and two in Thailand), 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.

- **2. Identifying Integrated IUFM and NbS Interventions (30–31 March 2021):** The second session focused on the Step 3 of the IUFM process, presenting the hybrid solutions and the anticipated benefits for the two Vietnamese case studies (one in Phu Quoc and the other in Ho Chi Minh City). 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.

- **Valuing and comparing IUFM solutions (18 June, 26 November 2021):** A final session was held separately for each case study 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 is to test the assumptions in the model with participants to ensure their appropriateness.

1. Define your urban system context

1.1. Growth creating both opportunities and challenges

Located 120 km from Rach Gia City and 45 km from Ha Tien City, Phu Quoc City plays a strategic role in the socio-economic development of Kien Giang Province. Known as 'Pearl Island', Phu Quoc is also the largest island in the country, and has become a popular destination for foreign and domestic tourists. In December 2020, the National Assembly Standing Committee passed a resolution establishing Phu Quoc City from March 1 2021, becoming the first island city in Vietnam.

Historically, Phu Quoc's economy was based on fishing and agriculture. Over the past 10 years, the city has posted high and stable economic growth, attributed to fast-growing tourism and service sectors and significant infrastructure investments. The number of tourists has been increasing steadily in recent years, reaching over 5 million in 2019, yielding an estimated revenue of more than 5.25 trillion VND (over USD 200 million). Under the Phu Quoc Construction Master Plan, the island is envisioned to become an international destination and a science and technology hub for the southeast Asian region, balancing economic development with sustainability and preservation of historic monuments and cultural heritage. The plan broadly covers all sectors, with a focus on technical infrastructure – roads, airports, ports, electricity, water supply, drainage and wastewater management, solid waste management – and on tourism facilities – resorts, eco-tourism and forests.

Situated within Duong Dong catchment, Duong Dong ward is the largest urban agglomeration in the city (with a population of approximately 45,000) and constitutes the administrative and economic centre. Phu Quoc night market, and long, straight beaches are major attractions in Duong Dong ward, although much of the beachfront is privatized; public access is limited with access mostly via hotels.

Figure 4: Beachfront in Duong Dong Town (left), Phu Quoc night market (right) – one of Duong Dong Town's main attractions.
Sources: Project team, 2020 (left), Marco Verch (right).

Concerns are emerging that continued expansion of the tourism sector together with rapid urban growth are placing significant pressure on water resources and endangering the island's unique ecosystems. Phu Quoc faces an array of critical challenges related to water resources, including water scarcity in the dry season, localized flooding and environmental pollution.

With only 16–17% of annual precipitation falls in the dry season, water scarcity has become a significant concern, particularly in Duong Dong ward. Long periods of hot days, little rainfall

and dissipated stream flows mean surface water storages at Duong Dong reservoir experience significant decreases in dry season.

The Duong Dong water supply system (WSS) – the only centralized public water supply network in Phu Quoc City – sources raw water from the Duong Dong reservoir – the island's only major storage basin with an area of 16 km^2 and design capacity of 4.13 million m^3 (Figure 5). The Duong Dong WSS operates at maximum capacity 24,000 m^3/day, and provides water supply services for all of Duong Dong ward, and parts of An Thoi ward and Duong To commune. For example, in March 2020, Phu Quoc City People's Committee reported water level in Duong Dong reservoir decreased by 5–6 cm on average every day. Such drops in water availability often force Duong Dong WWTP to reduce its production to 70–80% of capacity, resulting in water supply scarcity for people and tourists in Duong Dong ward. Under the current meteorological conditions and with existing reservoir operating rules, simulations suggest water demand would exceed supply on 470 days over 20 years, with a maximum drought duration of 93 days.

For other areas of the island, communities and businesses mostly draw water directly from aquifers, causing concerns about unregulated extraction and over-extraction.

Figure 5: Existing Duong Dong WSS.
Source: Project team.

Solid waste and wastewater volumes have increased consistently over the past decade, but civil infrastructure growth has not kept pace. The 2 most populated areas on the island, Duong Dong and An Thoi wards, experience the worst problems with domestic solid waste. Together, they account for over 52% of the total volume of domestic solid waste produced per day (100 tons). The island has no formal waste treatment system, and the remaining landfill in Cua Duong commune is quickly becoming overloaded. The majority (70%) of the island's domestic wastewater is only preliminarily treated by septic tank while the rest is discharged directly to open channels and water bodies.

Environmental pollution, including a serious problem of plastic waste, affects residents' quality of life, threatens natural habitats and biodiversity and hinders the growth potential of the island's tourism sector. Surface water pollution occurs in almost all rivers and creeks, particularly the ones flowing through residential areas such as Duong Dong River and Ong Tri Creek. The situation is most serious in dry season and is easily observed – water surfaces are commonly covered in floating rubbish, black water with bad odour is common, and oil slicks are often evident on the water surface (Figure 6).

Figure 6: Dong Cay Sao landfill in Cua Duong commune (left) and pollution at Ong Tri Creek flowing to Duong Dong River (right).
Source: Project team.

1.2 Planned infrastructure improvements

With these concerns, sustainable resources management is among the top priorities of the Governments of Kien Giang Province and Phu Quoc District. The Phu Quoc Construction Master Plan developed by Kien Giang PPC emphasizes developing water resources infrastructure across the island to ensure adequate access to water for all communities as well as to improve drainage conditions and address wastewater management. To address the most critical elements of the master plan, Kien Giang PPC is currently developing a proposal for a Sustainable Water Management Project (SWMP) under the World Bank.

The SWMP will include large scale investment to:

- construct the Cua Can multi-purpose off-stream water storage reservoir to increase the island's water security for the dry season and build climate change resilience
- construct a 20.3 km of stormwater drainage network
- establish a separate wastewater collection and treatment system, which includes Duong Dong WWTP with a capacity of 10,000 m^3/day, about 170.5 km of collection sewers and about 8,000 household connections.

Phu Quoc City is also calling for new investment for a solid waste treatment facility in Ham Ninh commune, which previously operated but closed in 2020. A second solid waste treatment facility is planned in Cua Duong commune to be completed by 2030.

As part of an enhanced drainage network, the planned Duong Dong retention basin is located adjacent to Nguyen Chi Thanh Road and Doan Thi Diem Road in Duong Dong ward, approximately 5 km from the estuary (Figure 7). About 150 households, totalling about 600 residents, currently reside on the site. The residents hold a certificate of agriculture land use right; i.e. the land is legally perennial agricultural land.

The area is currently a natural channel of Duong Dong River. Multiple wetland plants are present, including *Melaleuca, Rhizophora apiculate, Hibiscus tiliaceus, Sonneratia, Annona glabra* (Figure 8). Encroachment is common, since most residents have settled on the land informally.

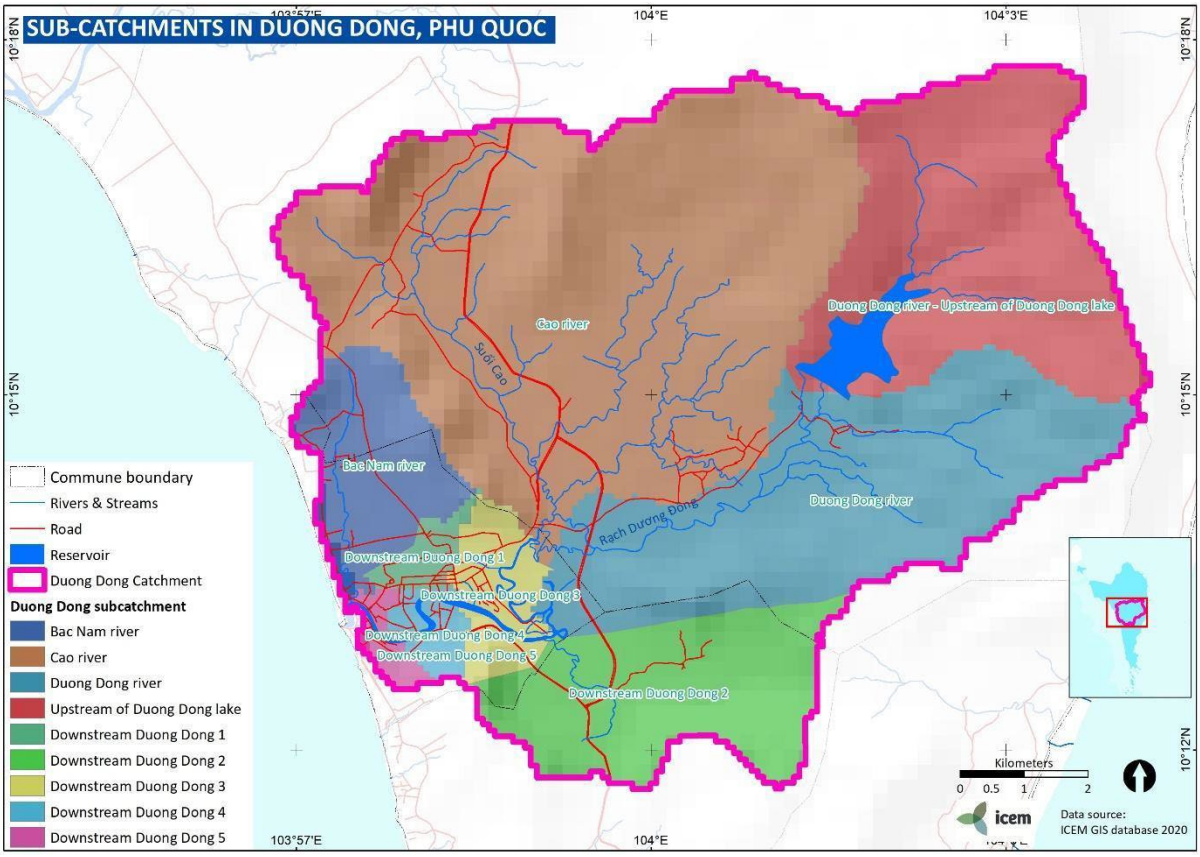


Figure 7: Wetland ecosystem in the planned retention basin.
Source: Project team.

Figure 8: Wetland ecosystem in the planned retention basin.
Source: Project team.

1.3 Sustainability initiatives on the island

Recognising these challenges and the threats they pose to the island's communities, economy and environment, several sustainability initiatives have emerged in recent years. Ecotourism and sustainable tourism are on the rise, and several large hotel chains have incorporated circular economy principles into their operations. For example, Radisson Blu Phu Quoc was the first partner to collaborate with La Vie Water for the 'La Vie Glass' project to encourage the hospitality industry to use glass bottles and other environmentally friendly materials instead of plastic. Radisson Blu Phu Quoc also runs the Radisson Blu Bee Garden to educate communities and visitors on the importance of honeybees and to support local food sustainability. Bamboo Step supplies a number of the major hotels with bamboo straws including Radisson Blu, JW Mariott and Fusion.

Outside of the hospitality industry, several initiatives are tackling sustainability, focusing on plastic waste. The World Bank ProBlue program (implemented jointly with the International Finance Corporation (IFC)) supports Government of Vietnam plastic waste reduction solutions. The program has three objectives (Figure 9).

Figure 9: Objectives of World Bank's ProBlue project.
Source: World Bank.

Chapter 5 provides further examples of public–private and community collaboration supporting more sustainable waste management on Phu Quoc Island.

2. Undertake a flood risk assessment

2.1 Flood challenges in Phu Quoc City and Duong Dong ward

Phu Quoc receives average annual precipitation of about 3,000 mm. Rainfall is unevenly distributed throughout the year, falling predominantly in the rainy season from May to November which accounts for 80% of the annual rainfall. During the rainy season, due to the island's moderate to steep topography, high precipitation levels quickly generate overland flow which then drains into the stream networks. With few major natural or anthropogenic storages, a large proportion of rain is converted to runoff and descends to the island's few coastal estuaries before being discharged to the sea.

The coverage and capacity of formal drainage services are very low. Only Duong Dong ward (and An Thoi ward) have some form of drainage and flood management (a combined system). However, these ad hoc and poorly maintained systems are increasingly inadequate to handle large amount of precipitation in a short period. Poorly planned urban development, increased impermeable surfaces, encroachment and blockages of natural drainage channels such as Duong Dong River and Ong Tri Creek (from rubbish and inadequate dredging) have disrupted Duong Dong's natural drainage mechanisms. As a result, floodwater does not drain fast enough to the sea during heavy rainfall events, causing localized flooding each rainy season. Such flooding is exacerbated by tidal effects at the estuaries.

In August 2019, unprecedented heavy rains hit Phu Quoc, which received 1,170 mm of rain over 10 days (accounting for up to 48% of average annual rainfall) (Figure 10). Island-wide, 8,424 houses were flooded, and 23 other houses collapsed, subsided/ cracked or lost their roof. Total estimated housing damage was 83 billion VND, or over USD 3.6 million. Over 60 km of roads were flooded and damaged, with average depth of 0.7 m. Almost 2,000 people had to be evacuated.

Figure 10: August 2019 flooding in Phu Quoc.
Source: Tuoi Tre News.

Duong Dong ward was particularly badly affected by the flooding, accounting for 65% of flooded houses and 24% of flooded roads (Figure 11). Main roads that were flooded included

Tran Phu Road (4 km, 90 cm deep), Cach Mang Thang 8 Road (2 km, 120 cm deep), Nguyen Trung Truc Road (1 km, 100 cm deep) and Mac Cuu Road (1 km, 130 cm deep). In residential areas of Duong Dong ward, average flood depth was 50 cm, disrupting local communities and tourists and damaging household appliances. Heavily developed residential areas and technical infrastructure contributed to this disproportionate impact.

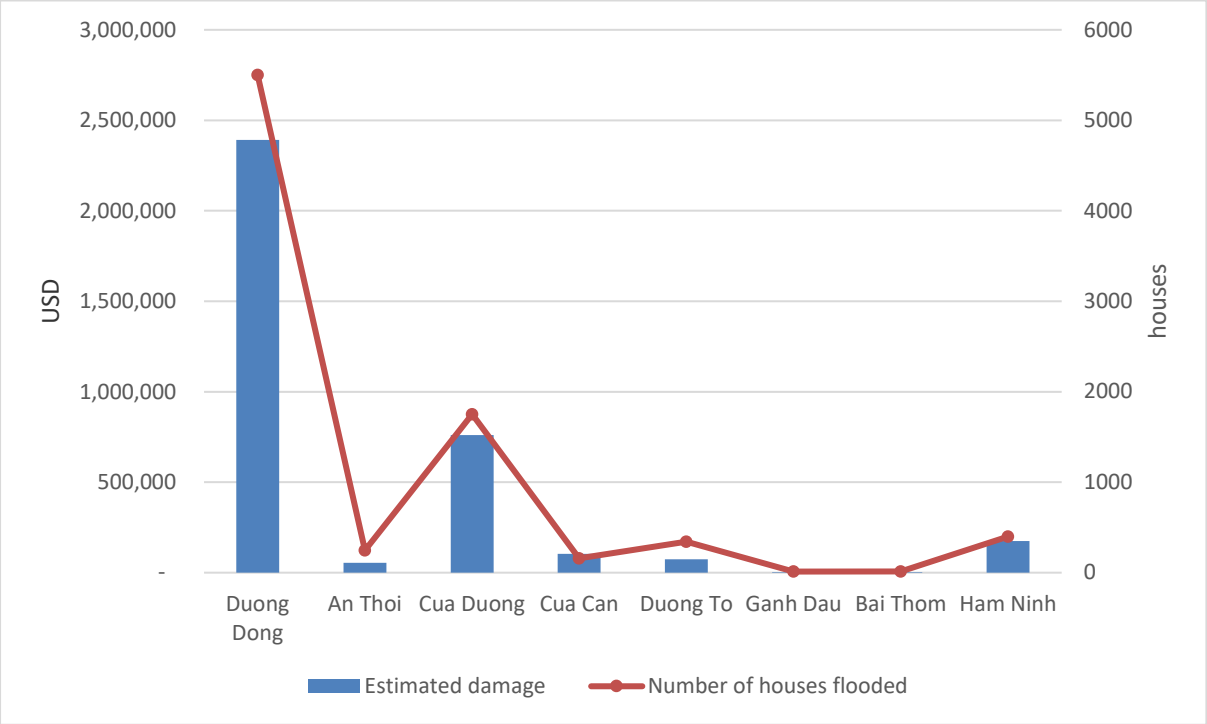


Figure 11: Number of houses flooded and associated damage by administrative unit in 2019 historical flood event.

Source: Economic Division, Phu Quoc City People's Committee, 2020.

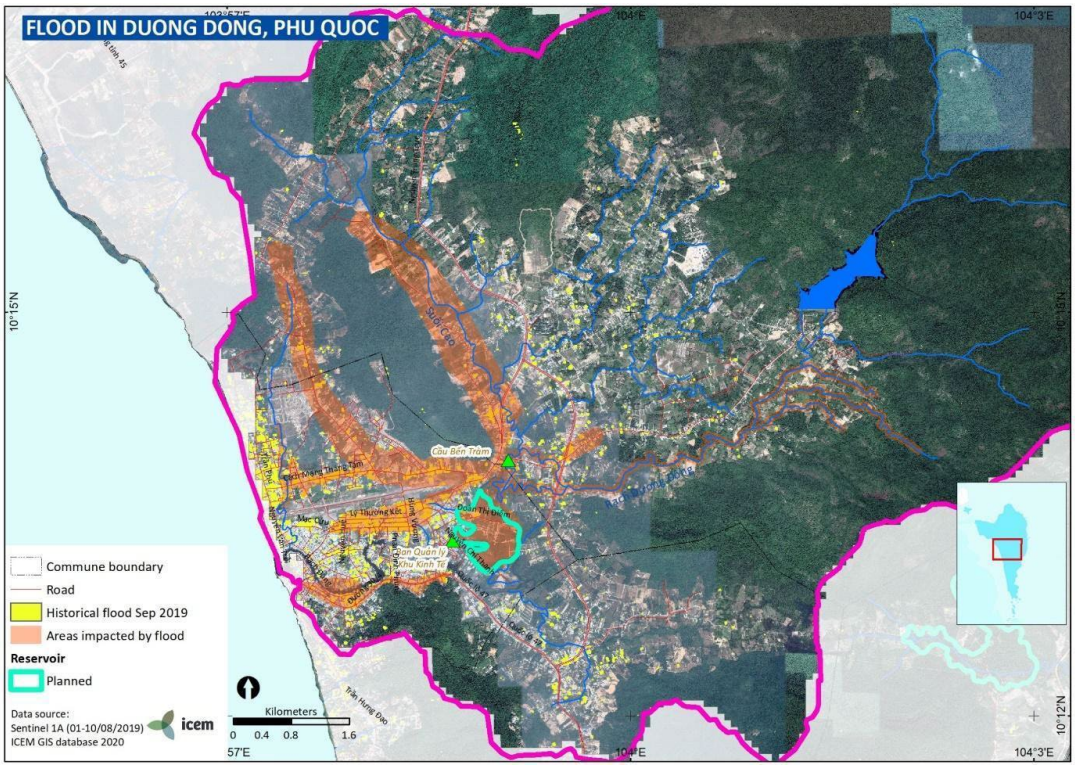


Figure 12: Historical flood extent in Duong Dong Town.
Source: Project team.

Duong Dong ward is prone to both pluvial and fluvial flooding. Projected increases in both average precipitation in the wet season – i.e. daily maximum rainfall and 5-day maximum rainfall – mean pluvial flooding is expected to worsen in both magnitude and intensity. With limited data available, indicative results of HEC-RAS hydraulic modelling conducted in the ongoing *Phu Quoc Integrated Water Resources Management Assessment (IWRMA)* project showed the water level peaked at a maximum of 2.0 m AHD for an event of maximum hourly rainfall of 72 mm.

In terms of fluvial flooding, HEC HMS catchment hydrological rainfall runoff modelling for the IWRMA study (ICEM 2021) indicated a 50-year average recurrent interval (ARI) event would result in a maximum flood height of 2.17 m AHD under climate change scenario RCP4.5 to 2050.

An additional significant issue across Phu Quoc is the anticipated increased storm surge heights from climate change. At present, the expected storm surge height under a severe event is 1.2 m. However, this height increases to 2.0 m by 2050 and to 2.5 m by 2100 due to climate change under the RCP4.5 and RCP8.5 scenarios respectively. The lower reaches of the Duong Dong River are of concern, facing the potential impacts of combined storm surge and flood events. This case study did not directly consider solutions to coastal storm surge, however future defence responses such as barriers, breakwaters and gates would need to be applied for both the conventional and hybrid scenarios.

Expected impacts from flooding in Duong Dong ward are:

- travel disruption
- damage to houses
- business closures
- pollution due to overflow of wastewater and floating garbage in floodwaters
- potential loss of life during extreme events.

3. Identify context-appropriate solutions

3.1 The conventional solution

The threat of flooding in Duong Dong ward is such that 'doing nothing' is no longer an option. The conventional solution outlined in the 2014 Duong Dong urban zoning plan is to widen the Duong Dong River downstream, from a planned retention lake on the eastern outskirts of the ward to the coast: an area approximately 5 km by 100 m wide, with dredging of an additional 2 m from the current river bed depth. Levees will be constructed on both banks of the river, with levee height of 1.8 m for the 3 km section from the estuary to the Hung Vuong Bridge and 2.2–3.0m for the 2 km section from the Hung Vuong Bridge to the planned retention lake.

The conventional response is expected to provide a strong level of flood protection by increasing floodwater storage and the drainage capacity of the Duong Dong River to mitigate flood risk during extreme rainfall events, equal to a 100-year ARI event. During such an event, the conventional response would decrease downstream water levels by 1.7m.[3]

Since downtown residential areas are heavily developed on both sides of the river, widening it would involve acquiring large areas of urban residential land and resettling thousands of people. Compensation would be significant, and social disruption would be expected.

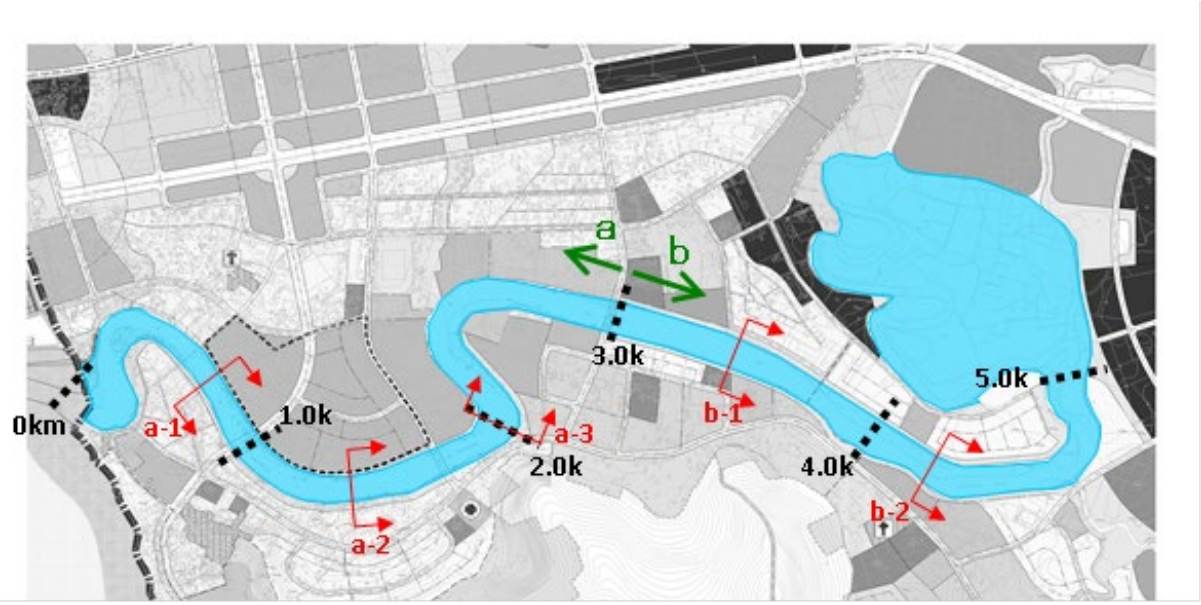


Figure 13: Planned widening of Duong Dong River for flood mitigation.
Source: Phu Quoc Construction Master Plan.

[3] Sekkei Civil Engineering Ltd (2014). *Duong Dong Urban Zoning Plan*. Department of Construction. Kien Giang Province People's Committee.

3.2 The hybrid approach

The hybrid approach instead focuses on the planned Duong Dong retention lake, proposing to develop it into a multifunctional freshwater wildlife conservation park with a total area of 46 ha (Figures 14 and 15).

The components of the approach are as follows:[4]

1. a retarding basin to reduce flooding to the downstream community around Duong Dong River
2. a constructed wetland for stormwater harvesting and purification
3. an eco-tone restoration to serve as an ecotourism destination in Duong Dong ward
4. higher ground for high quality development and land reserved for resettlement
5. a combined waste recycling facility to demonstrate circular economy by turning organic waste and sludge into compost or biogas.

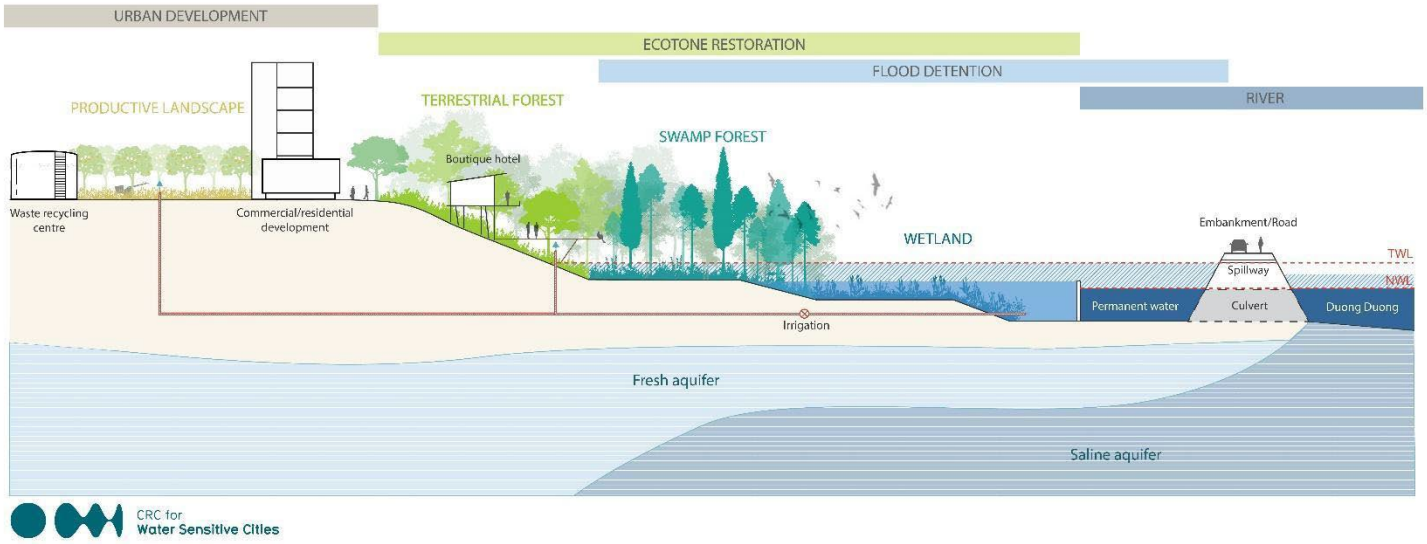


Figure 14: Transect overview of the components of the hybrid approach.
Source: Project team.

[4] Managed aquifer recharge (MAR) was initially included as part of the hybrid strategy. However, it was removed after feedback from expert consultation workshops and from findings from the ICEM IWRMA project which indicated the high groundwater table made the site unsuitable for MAR.

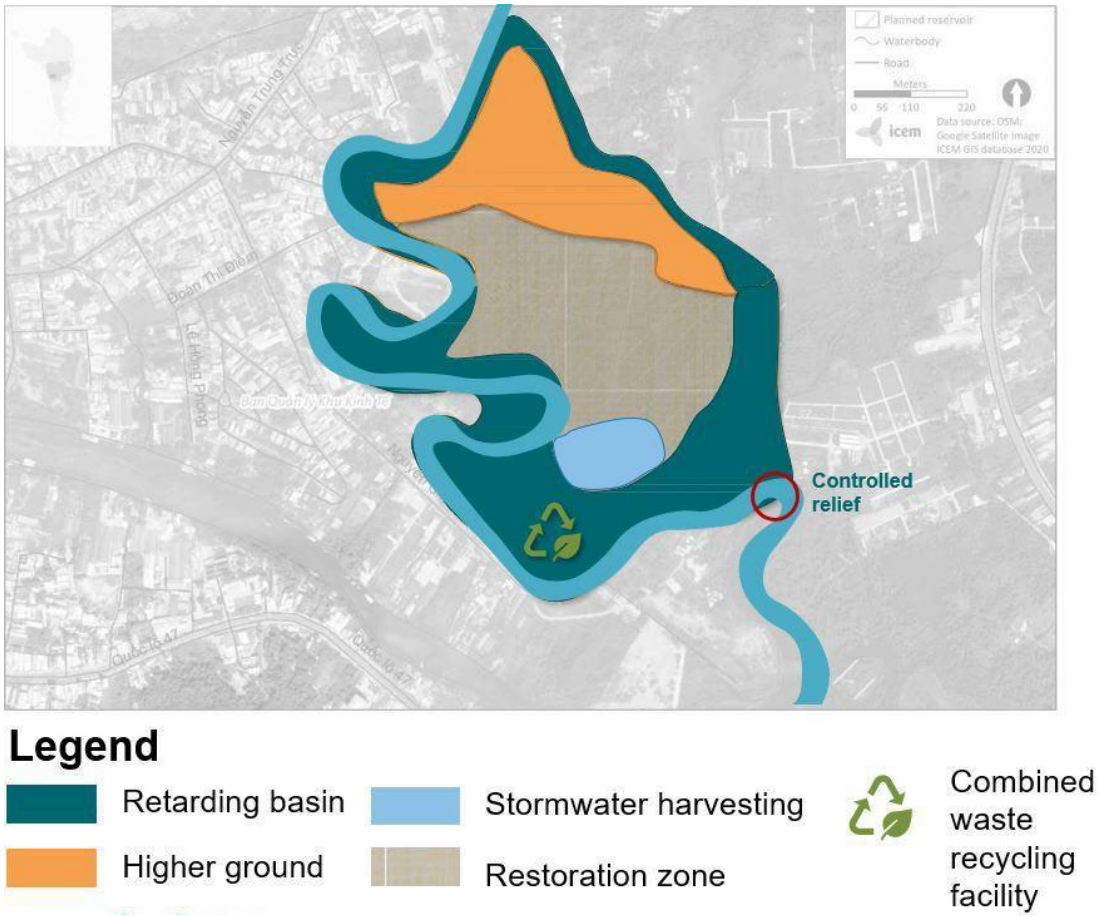


Figure 15: Elements of the hybrid solution overlaid on map of the current site.
Source: Project team.

The hybrid solution capitalizes on the Duong Dong River's pre-existing natural channel. It would be significantly cheaper to implement due primarily to the lower compensation costs for acquiring land and resettling people, given the land is designated as perennial tree cultivation land.

The hybrid approach offers a range of social, economic and environmental co-benefits:

- increased flood protection for a 1-in-30-year flood event
- additional water supply from stormwater harvesting (reducing the recurring cost of park maintenance)
- improved amenity and recreational opportunities
- improved biodiversity
- delayed cost of infrastructure investment in a solid waste treatment facility in Cua Duong commune
- revenue generation from compost sales
- minimized social disruption via an in-situ resettlement scheme.

Each component of the hybrid strategy is explained in detail below.

3.2.1 Retarding basin

The first component is to design the wetland park as a retarding basin, so that water will backup from the downstream bottleneck to inundate a larger area, mitigating the river's limited

drainage capacity. Floodwater will be released downstream in a controlled way through a relief point (Figure 16, top) to manage peak flows and decrease flood risk to the downstream urban area. This component would involve equipping the downstream interface with Duong Dong River with appropriate hydraulic structures including a weir, gates, pumps and pipes (to enable the flood detention operation) and an embankment/levee immediately downstream of the wetland park (to contain the water). This feature could be integrated into the conservation park design as an aesthetic, landscaped walkway or road (Figure 16, bottom).

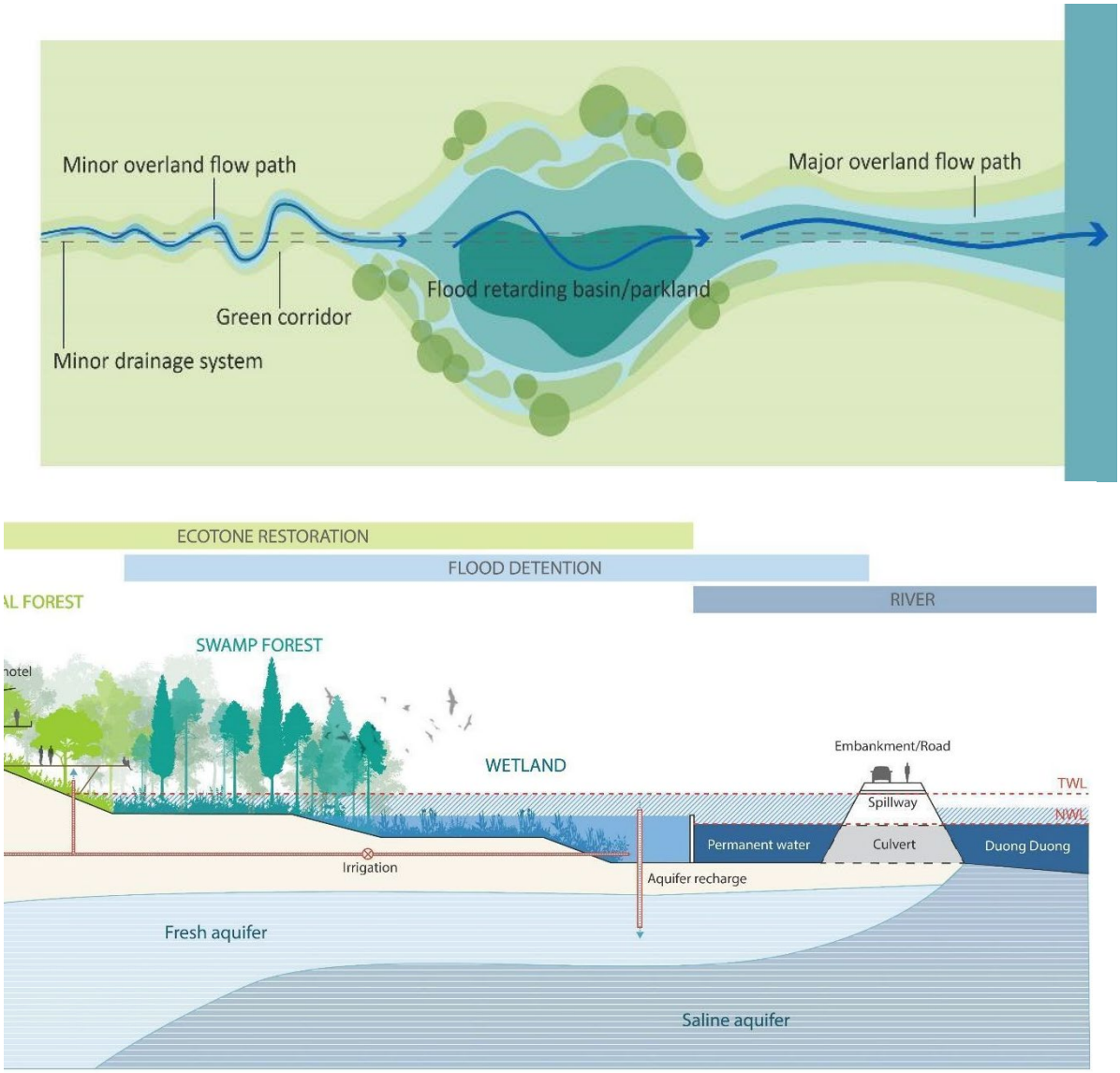


Figure 16: Indicative design of retarding basin showing controlled relief point (top) and transect overview showing placement of the spillway and culvert, integrated as a road or walkway (bottom).
Source: Project team.

The total area of the retarding basin is estimated at 42.5 ha, including a retention lake as permanent water body, the wetland and the swamp forest. The area will be excavated to 5 m compared with the current bed, and shaped in a terraced form. A 2.5 km levee will contain the floodwater.

Compared with the conventional approach, modelling results in the Duong Dong urban zoning plan indicate a lower overall protection level against extreme flood events, but still a significant

benefit compared with the do-nothing scenario. The design provides an approximate protection level against a 1-in-30-year ARI event, which exceeds the minimum flood protection design standards for comparable infrastructure (against a 1-in-10-year event).[5]

3.2.2 Constructed wetland and stormwater harvesting

The constructed wetland component functions as a water cleansing system that will harvest stormwater discharged from the upstream Duong Dong catchment and improve the stormwater quality as it flows into the urbanized area. Although the upstream area is sparsely populated, there is no formal wastewater system so households discharge domestic wastewater into open channels or natural water bodies which then flow into the river.

To improve water quality while maintaining a strong level of flood protection, an 'offline' system is recommended, which means the constructed wetland runs parallel to the Duong Dong River. A divergent structure will be installed to divert a proportion of the dry weather flow into the wetland for treatment, with high flows allowed to bypass via an adjacent waterway (Figure 17). In the system, water flows through a series of densely vegetated wetland species, where it is treated via microorganisms in reedbeds and other aquatic plants, whose root systems break down the contaminated effluent. The water is then channelled back into the river mainstream, or harvested for internal public uses such as irrigation, road cleaning and firefighting. In Vietnam, local species that have been successfully used in wetland systems include *Phragmites australis* and *Typha angustifolia.*[6] In the wetland, a gross pollutant trap can help manage some of the solid waste problems by trapping litter and coarse sediment.

The constructed wetland will have an area of 1 ha, and the stormwater harvesting system will have the capacity to harvest up to 350 m^3/day of stormwater. When water levels are normal, water in the retention lake can be recirculated through the wetland to maintain water quality and the park's amenity value. The wetland is a part of the retarding basin, so during flood events, when floodwater exceeds a certain threshold, the wetland will be flooded.

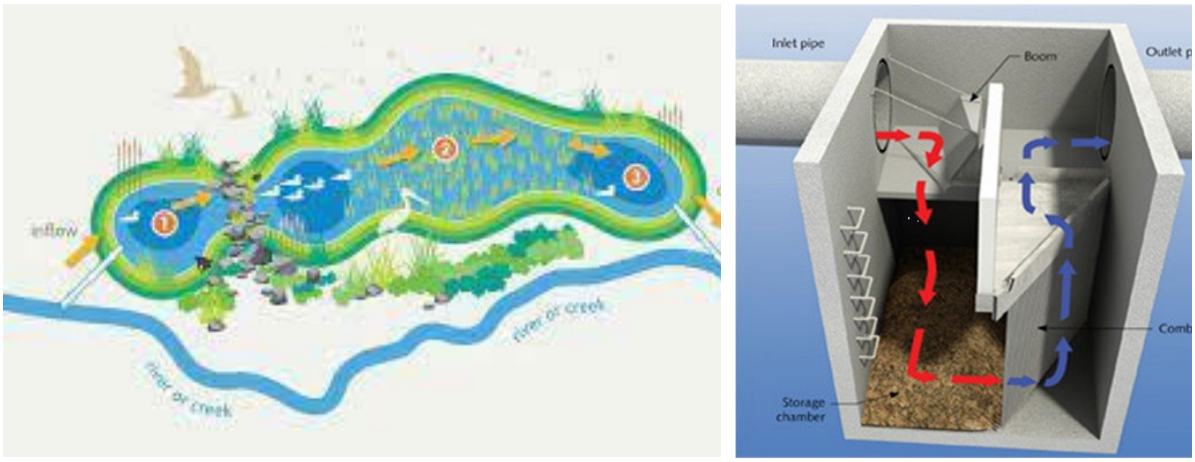


Figure 17: Offline constructed wetland system (left), gross pollutant trap system (right).
Sources: Melbourne Water (left), City of Melbourne (right).

[5] See TCVN 7957:2008 Drainage and sewerage – External Networks and Facilities. Note there is no national design standard for retention/detention lakes.
[6] Anh, B.T.K. (2018). 'Selection of suitable plant species for wastewater treatment by constructed wetland at the Formosa Ha Tinh Steel Company', *Vietnam Journal of Science and Technology*, 56(2C), 157–163.

3.2.3 Eco-tone restoration

A small scale, accessible alternative to the mainly beach-based tourism offerings on Phu Quoc island, focusing on conservation and showcasing of native species presents a significant and unique draw for tourists. This component would be particularly useful for Duong Dong ward which lacks attractions besides the beachfront. Such an initiative would also capitalize on the increasing interest from domestic and international visitors in ecotourism.

The hybrid approach incorporates a 10 ha eco-tone restoration area featuring both aquatic and terrestrial fauna and flora. Forests and wetlands showcase a diversified habitat, with viewpoints for wildlife observation. Amenity for eco-tourism could be designed on walkways above the lake, elevated to withstand various water levels. It could be integrated into the local tourism activity program with guided tours to show tourists species native to Phu Quoc and the Kien Giang Biosphere.

Tourism facilities could be developed at designated point so visitors can observe wildlife. The facilities could be architecturally designed on platforms to easily cope with temporary rises in water levels.

Currently, local residents and tourists have limited amenity and recreational opportunities and limited public access to the beachfront in Duong Dong ward. The conservation park would create significant amenity and recreational benefits for both these groups.

The following design renderings illustrate how the wetland conservation park could be constructed as a dynamic and natural habitat during the dry season, minor and extreme flooding events.

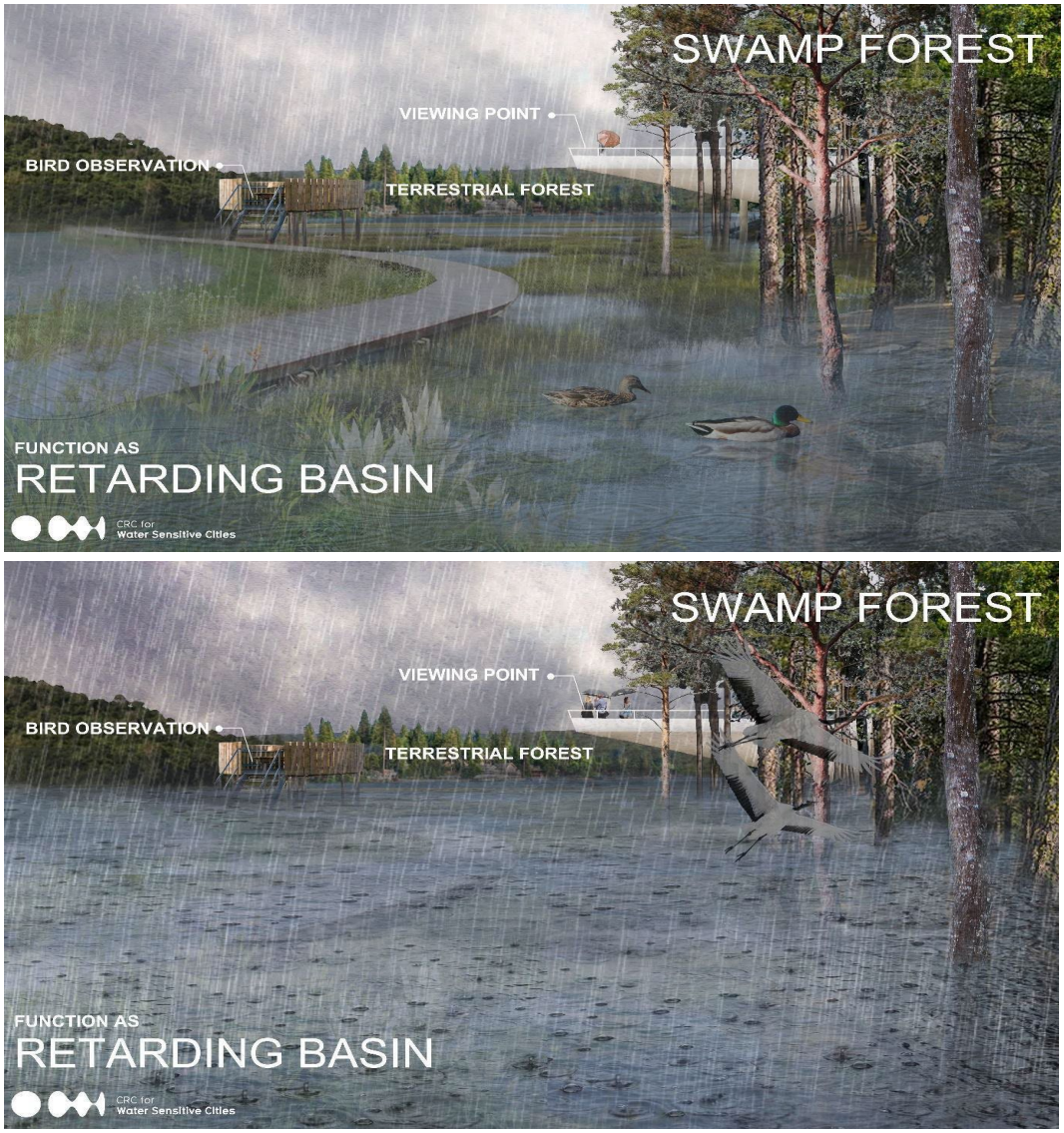


Figure 18: Design of wetland conservation park with landscaped features for recreation and nature observation during dry season (top), minor flooding (middle) and extreme flooding events (bottom).
Source: Water Sensitive Cities Australia.

3.2.4 Higher ground for commercial and residential development

This component takes advantage of the cut materials from the soil excavation to create the retarding basin and fill higher ground to create a gradient in the park permanently above inundation levels.

The higher ground will be reserved to develop both an affordable apartment building and high-quality development properties such as luxury apartments, boutique eco-hotels or restaurants. This

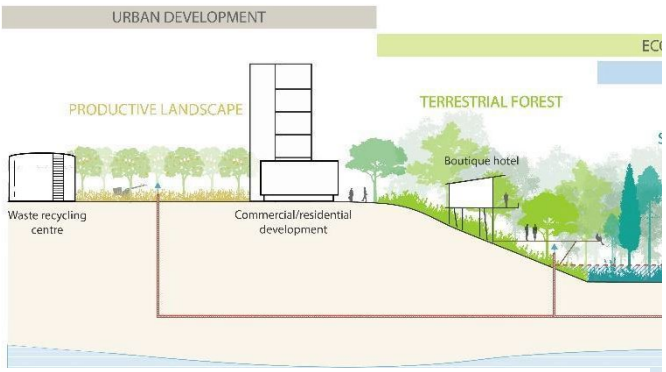


Figure 19: Higher ground for future commercial and residential development.
Source: Project team.

component capitalizes on the projected increase in land value associated with the conservation park.

One of the anticipated challenges for this component is acquiring land from residents currently residing within the site. Creating this higher ground with developable land could offset some compensation costs, via land exchange from the current low-value agricultural land, to the higher value apartments.

3.2.5 Combined waste recycling facility

Phu Quoc generates a significant amount of organic waste such as food waste, particularly from its hospitality industry. Instead of placing pressure on the island's at-capacity landfill sites, parts of the collected food waste and organic segments of municipal waste could be beneficially reused, e.g. turned into compost. There will also be demand to manage sewage sludge safely and sustainably when the Duong Dong WWTP comes online. Sewage sludge contains organic matter that can be transformed into energy and/or green chemicals. Moreover, resource recovery from these wastes has become an increasing new focus of wastewater management, to develop more sustainable processes in a circular economy approach.

The common approach to recover these resources is via anaerobic digestion. This series of biological processes involves microorganisms breaking down biodegradable material in the absence of oxygen. It has been effectively tested and is considered the most commercial method to convert organic wastes such as municipal activated sludge and the food and organic portion of municipal waste into resources such as compost and methane-rich biogas.

Anaerobic co-digestion is a technology providing simultaneous digestion of different solid and liquid wastes. The technology achieves more a appropriate carbon-to-nutrient ratio by co-digesting nutrient-rich and highly COD-concentrated wastes. Further, co-digestion provides higher efficiency in terms of land and equipment utilization by digesting various waste streams in a single facility. The end product of this process – compost – could reduce demand for imported agricultural fertilizer. This strategy demonstrates an opportunity to introduce and promote circular economy principles on Phu Quoc Island, and helps to relieve the solid waste management pressure on the inadequate system currently in place.

The proposed approach is to construct and operate a combined waste recycling facility that turns organic waste and sludge into compost using co-digestion via a public–private arrangement. The proposed facility will be located on the perimeter of the site and away from the zoned commercial and residential area with an appropriate buffer zone to dispel any poor odours for park visitors.[7] The facility has an assumed capacity to produce a maximum of 50 tons of compost per day and 1,500 tons of compost per year. This amount represents around three-quarters of the island's fertilizer consumption in 2020.

The compost could be sold at a below-market average price for organic fertilizer. Additionally, constructing a combined waste recycling facility could delay investment in a second solid waste treatment facility at Cua Duong commune by approximately 5 years.

Financial incentives for private engagement are drawn from the revenue generated from selling compost as an alternative to imported fertilizer. Engagement programs, such as educational visits by local schools and guided tours, can showcase innovative circular economy approaches as a unique tourism experience. Collaboration with the not-for-profit

[7] Another option is for it to be co located with future solid or liquid waste facilities.

sector could also be pursued, similar to programs for managing inorganic waste (see Chapter 1).

An alternative strategy could be constructing a bio-power facility using green waste, which uses the same anerobic digestion process. Biogas is then converted into electricity, which could be used onsite or sold to the electricity grid. This case study used composting because it has lower costs and lower technology and risk management requirements.

Figure 20: Workers sorting waste at a waste recycling facility (output 50 tons per day) in Quynh Coi, Thai Binh Province (top); composting area to turn organic waste into fertilizer for agriculture (middle); compost products produced from organic waste (bottom).
Source: suckhoemoitruong.com.vn.

4. Value and choose interventions

This section provides an overview of the results of the BCA. It compares the conventional solution and the hybrid approach as described in Chapter 3 to a 'do nothing' scenario. Costs were estimated in Vietnam Dong and converted to current USD. The cost and benefit components and assumptions across the 40-year project period can be found in the Annexes. 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.

4.1 Overall BCR

Overall, both options deliver a strong BCR. The conventional approach provides a stronger BCR of 3.28, with an NPV of USD 139 million, but at a much greater cost. The hybrid approach has a BCR of 2.81 and an NPV of USD 65 million. Compared with the conventional solution, it provides a broader range of benefits, includes more options for funding and has a lower financing requirement. This lower cost may free public funds for spending on other investment priorities.

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

	Hybrid (USD)	Conventional (USD)
Benefits	103,119,762	200,349,212
Costs	36,647,170	61,149,230
Net	66,472,592	139,199,982
BCR	**2.81**	**3.28**

Table 1: Comparison of overall BCR: hybrid (left) and conventional (right).
Source: Project team.

4.2 Comparison of costs

Table 2 and Figure 21 break down and compare the costs associated with the hybrid and conventional approaches. The hybrid approach represents just over half (56%) of the costs of the conventional approach. The high land acquisition costs from resettling and compensating thousands of people who live on both sides of the Duong Dong River account for the majority of the costs associated with the conventional solution.

In contrast, the hybrid approach involves resettling fewer people around the retention lake, and the land is zoned for agricultural purposes which lowers the compensation costs. To further minimize social disruption, the hybrid approach includes an in-situ resettlement scheme (see Section 3.2.4) with affordable apartment buildings. Some compensation costs could also be offset via land exchange from the current low-value agricultural land, to the higher value apartments.

Hybrid		Costs (USD)
1	Land acquisition	5,934,000
2	Fence construction around the park	1,011,360
3	Retarding basin	16,459,601
	Excavated soil	9,983,907
	Hydraulic structure	2,951,962
	Levee	3,523,732
4	Constructed wetland	
	Constructed wetland	103,200
	Stormwater harvesting	21,151
5	Eco-tone restoration	933,622
6	Waste recycling facility (co-digestion)	4,183,493
7	Higher ground	
8	Stormwater pipe	165,966
9	Electricity	22,627
10	Roads	509,579
Total		**29,577,174**

Conventional		Costs (USD)
1	Land acquisition	27,520,000
2	Levee construction – downstream Hung Vuong Bridge	12,093,448
3	Levee construction – upstream Hung Vuong Bridge	7,047,464
4	Deepening and widening the river	4,698,309
Total		**51,359,220**

Table 2: Comparison of capital costs: hybrid (left) and conventional (right).[8]
Source: Project team.

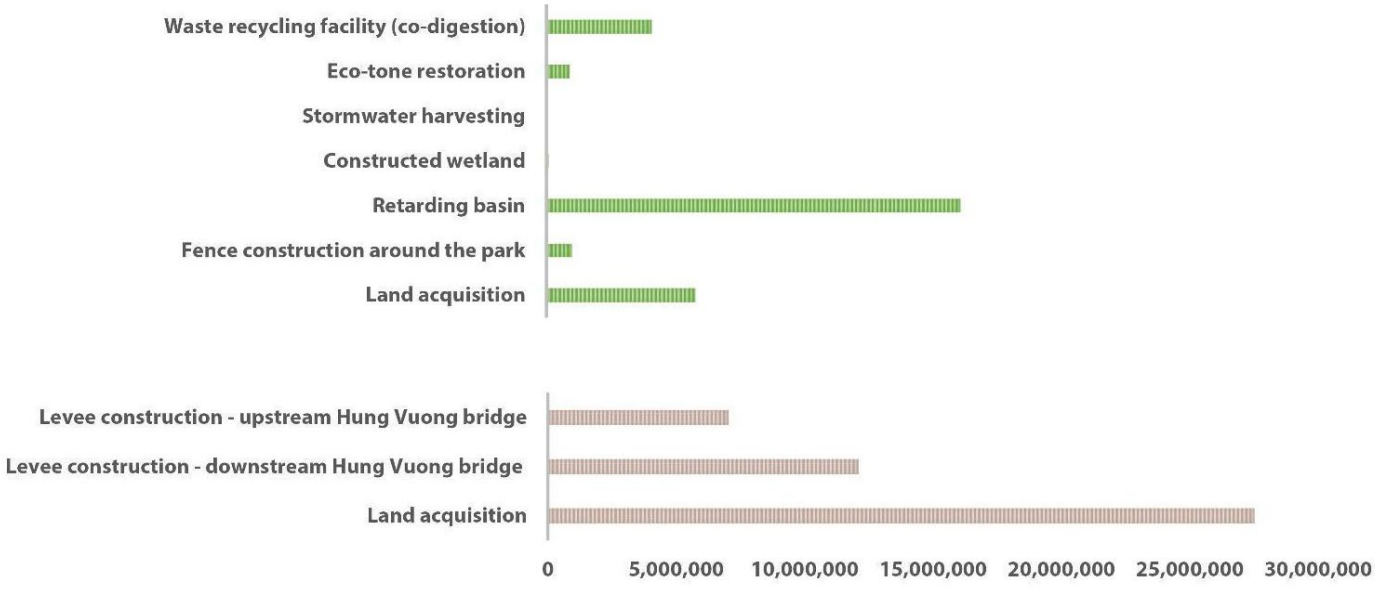
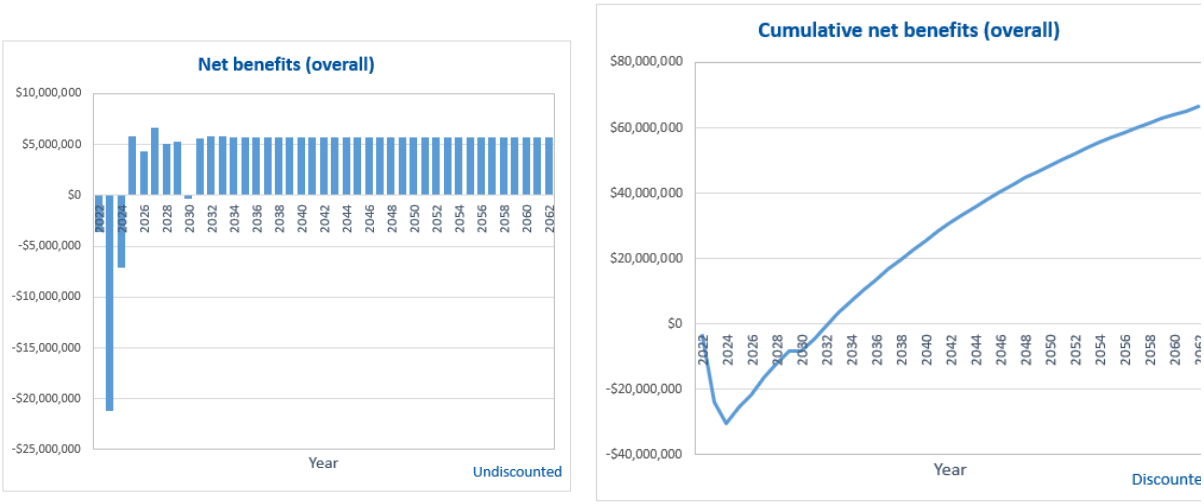


Figure 21: Comparison of capital costs: hybrid (top), conventional (bottom).
Source: Project team.

[8] 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.

Costs are mainly upfront for both options, while benefits accumulate over time. For both options, the cumulative benefits begin to outweigh the costs around 2030, or approximately 8 years after construction. The conventional approach has both higher costs and benefits.

Hybrid



Conventional

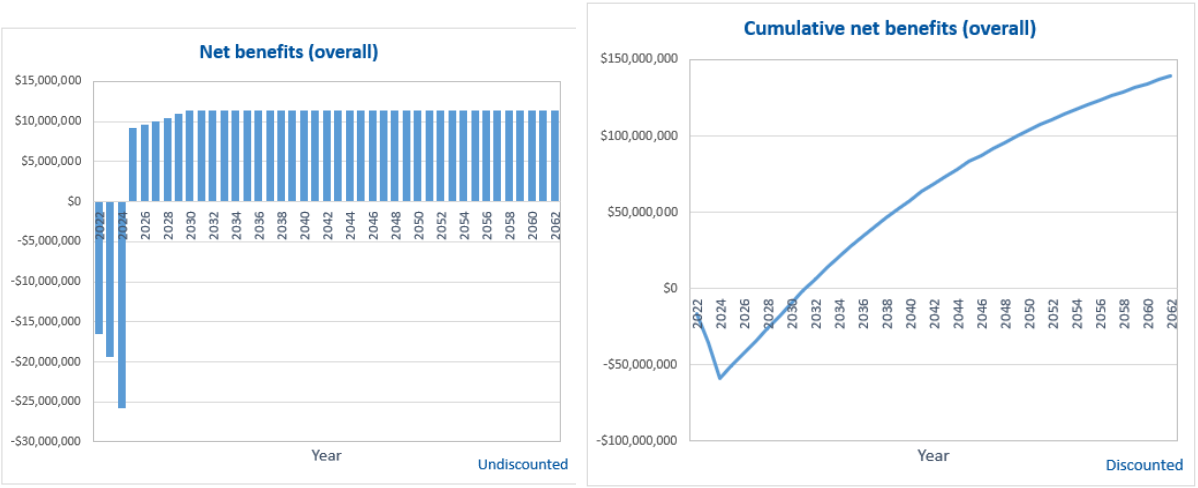


Figure 22: Comparison of net and cumulative benefits over time: hybrid (top), conventional (bottom).
Source: Project team.

4.3 Benefits

In the conventional solution, 100% of the benefits are associated with improved flood protection outside the park, i.e. the benefits from avoided flood damage to residents downstream. In contrast, the hybrid solution provides a range of benefits (Figure 23). By far the greatest benefit –representing 71% of total benefits or USD $103 million over 40 years – is flood protection outside the park. Other benefits include improved amenity and recreation for both local residents and tourists, revenue from selling compost from the combined waste treatment facility, the value from delaying infrastructure costs for waste treatment, lower costs arising from stormwater harvesting and reuse, and enhanced biodiversity values.

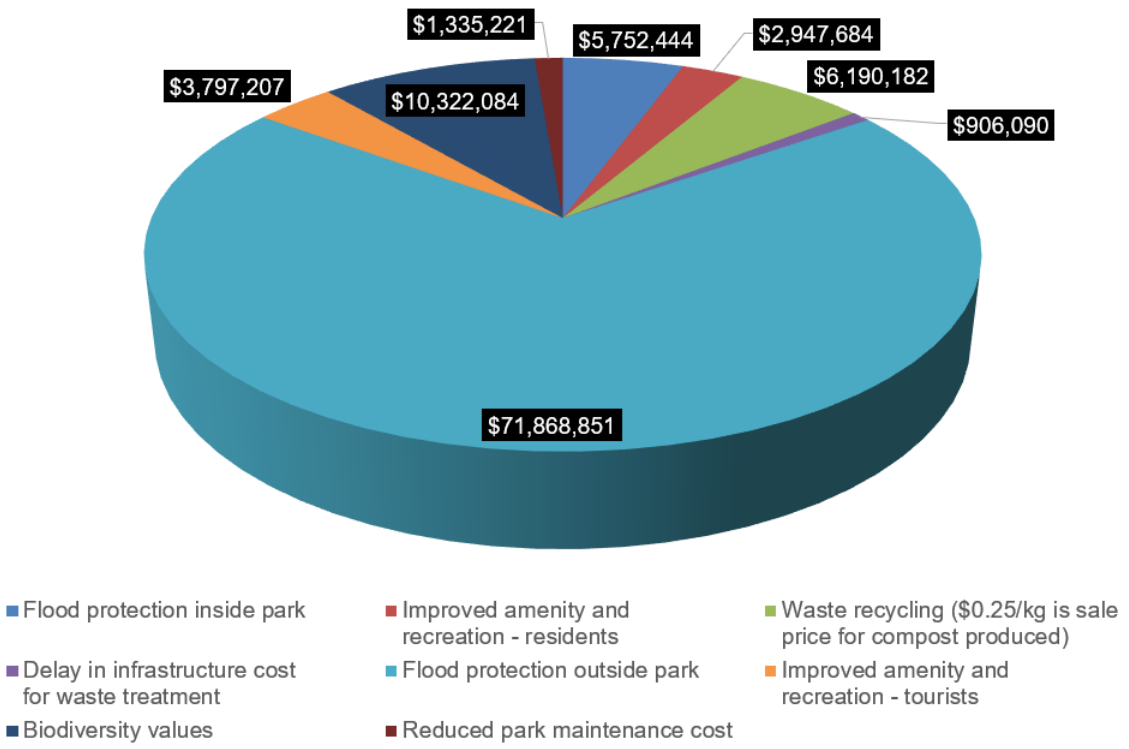


Figure 23: Benefit types and their value (hybrid solution).
Source: Project team.

4.4 Distribution of costs and benefits

In the conventional solution, the Phu Quoc City People's Committee (CPC) assumes 100% of the costs, while 100% of the benefits go to the downstream community. In contrast, the hybrid solution envisages the combined waste recycling facility being either fully privately owned and operated, or constructed and maintained under a public–private arrangement, alleviating some of the costs for the Phu Quoc CPC.

Benefits are also more distributed in the hybrid solution. While the downstream community is still the greatest beneficiary, other stakeholders also benefit – namely profits for the private company involved in the waste recycling, reduced maintenance costs for the Phu Quoc CPC, and amenity, recreational and aesthetic benefits for local residents (inside, outside and downstream of the park) and tourists.

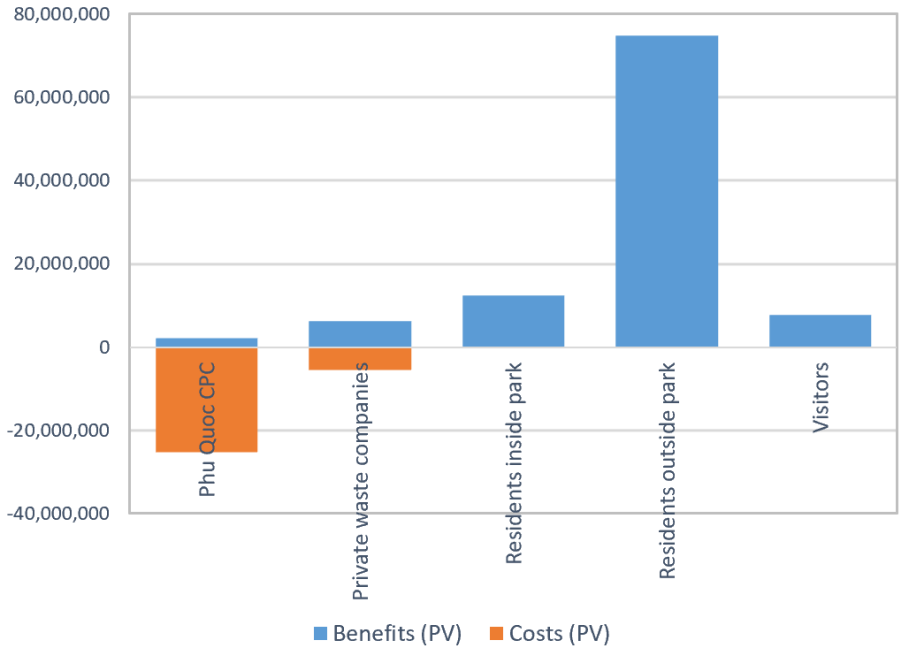


Figure 24: Distribution of costs and benefits (hybrid solution).
Source: Project team.

4.5 Sensitivity testing

This high-level strategic assessment adopted several assumptions to address data gaps, so sensitivity testing is important to check the robustness of the results and whether any elements of the approach particularly influence overall results. The project team tested the valuation of costs and benefits, discount rates and timeframes.

The results showed both the conventional and hybrid options provide a net benefit to the community even when costs and benefits are increased and decreased by 30% and simulations are run over 1,000 times.

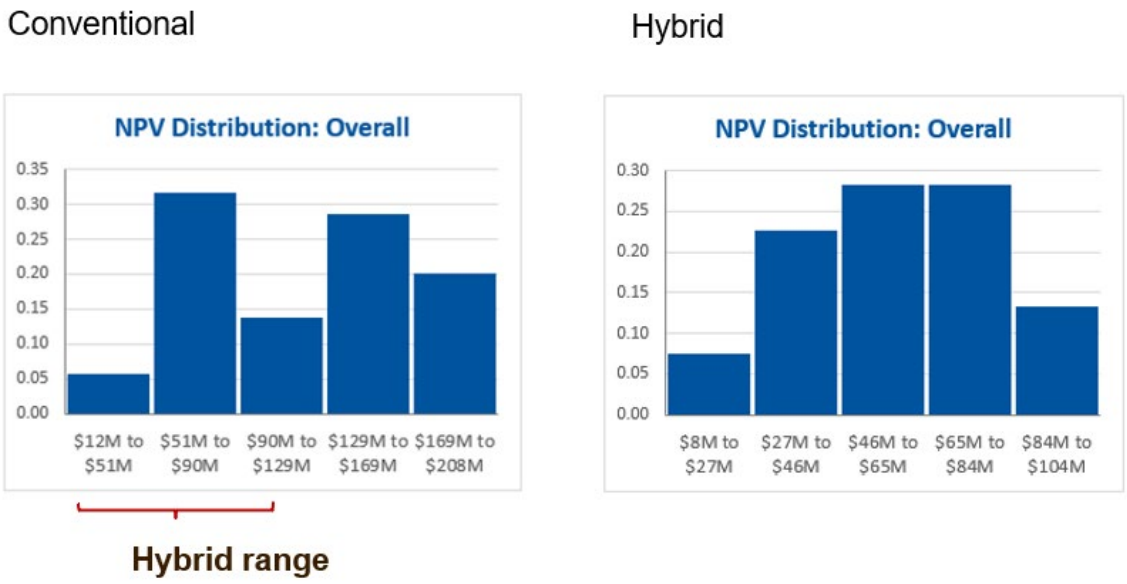


Figure 25: Range of outcomes identified through sensitivity analysis.
Source: Project team.

The results for both options are very sensitive to the assumptions about flood protection benefits, so further investigating these benefits should be a priority. In contrast, varying the discount rate to 2% or 6% does not change the overarching conclusions.

A much bigger range of economic outcomes is possible with the conventional solution given its much larger costs and benefits.

5. Identify appropriate funding and financing mechanisms

Vietnam has placed a high priority on green growth and climate resilience, shifting away from traditional models of growth to sustain the development gains of recent decades. The country adopted a National Green Growth Strategy (VGGS) and developed a corresponding Green Growth Action Plan. To finance the VGGS, Vietnam needs to mobilize huge investment capital, estimated to be at least USD 30 billion. Sustainable and equitable investment also needs to increase to achieve future policy and national strategy goals.

As Vietnam moves from a centrally planned to a market-oriented economy and from a low- to a middle-income country, the mix of available financing sources is changing. Official development finance, which is provided at concessional terms, is likely to decline both in relative importance and absolute volumes. Going forward, development assistance (ODA) will likely decrease even further with the country's graduation from the International Development Association (IDA) in July 2017 and the Asian Development Bank's (ADB) Asian Development Fund in January 2019.[9]

Responsibility for funding, financing and delivering public works has previously fallen largely on the public sector. Growing demand for infrastructure together with budget constraints and the reductions in access to foreign capital suggest public funding alone cannot meet future demand. For these reasons, alternative funding and finance mobilization strategies are needed to address a growing funding gap.

The *Duong Dong Freshwater Wildlife Conservation Park* case assumed a similar gap applies to meet future flood protection, green space and recreational needs in Duong Dong ward and across the island. The concepts and strategies included in the case study help bridge this gap by generating a broader range of benefits at a lower cost and unlocking additional revenue streams. Many of the ingredients needed to support the shift from concept to action are already in place but further evolution is needed.

Securing funding and financing requires aligning enabling policy, regulations and strategies that foster participation and innovation across the public, private and not-for-profit sectors. Effective comparison of conventional and innovative options ensures available funds are used to greatest effect. Pilot projects are a critical first step in this process, because they inform and refine the costs and benefits associated with innovation. Multi-stakeholder collaboration also provides opportunities for leveraging public funds by applying additional cost recovery options such as 'user pays' principles for tourists and park visitors where appropriate.

5.1 Enabling policy and strategy

As noted above, the Government of Vietnam has developed a VGGS, approved in Decision No. 1393/QĐ-TTg (25 September 2012) and a corresponding Green Growth Action Plan for 2014 – 2020 period, approved in Decision No. 403/QĐ-TTg (20 March 2014). The VGGS has the following visions:

- Green growth is an important part of sustainable development to ensure fast, efficient and sustainable growth while making a significant contribution to implementing the national climate change strategy.

[9] OECD (2019). *Transition finance country study Viet Nam: On the edge of transition*. June.

- Green growth must lead to increased investments in conservation, development and efficient use of natural capital, reduced greenhouse gas emissions and improved environmental quality, and thereby stimulate economic growth.
- Green growth is the cause of the entire Party, all people, every level of government, ministries, localities, enterprises and social organizations.

The VGGS also identifies activities including:

- Develop and implement masterplans for rainwater drainage systems, urban waste and wastewater collection, transportation and treatment systems. In areas that are highly vulnerable to climate change, infrastructure should be adapted to minimize economic losses.
- Develop green cities, ecological urban areas and green works.
- Green the urban landscape. Prioritize the allocation of public land to quickly expand the area of green coverage and water in urban areas, meeting the standards set for each city grade level. Stimulate investment and development of green space in urban projects and encourage communities, enterprises and households to mobilize resources to green urban landscapes.

Achieving the visions set out in the VGGS will require mobilizing the right scale and mix of funding and financing, and accessing public and private resources, both domestically and internationally. The VGGS itself calls for increased investment across sectors, including through public–private partnerships (PPPs) and international sources, and specifically calls to scale up domestic financing for green growth.

Kien Giang Province People's Committee issued Decision No. 17/KH-UBND (6 February, 2015) on the Action Plan to Implement Sustainable Development Strategy of Kien Giang Province to 2020. This planning document called for mobilizing resources from state budgets, IDA sources, the private sector, domestic and international organisations and individuals to effectively achieve sustainable development.

At a local level, the Phu Quoc Construction Master Plan lays out the strategy for enhancing Phu Quoc's reputation as an international tourism destination, as well as new aspirations for developing the island's economy as a science and technology hub for southeast Asian.

The solutions set out in this case study strongly align with these national, provincial and local strategies, particularly the master plan's focus on improving technical infrastructure (including drainage and solid waste management) and developing eco-tourism. All strategies promote private sector engagement in delivering climate resilient infrastructure. Achieving these visions requires the right scale and mix of funding and financing from public and private sources.

5.2 Recognizing and valuing investment options that support policy objectives

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 this case study shows, the IUFM approach balances centralized and decentralized solutions as well as green, gray and non-structural solutions that reduce the overall costs to be financed. The Duong Dong multifunctional conservation park highlights the additional value of NbS in supporting large investment. It is important for public authorities to include the sorts of values highlighted in this case study in investment decisions as a business-as-usual activity.

A stronger business case clearly aligned with government policy objectives not only increases the likelihood of public funding support, but information on the size and distribution of benefits

can also be used in community education and engagement, which in turn helps mobilize private action for public and private good.

5.3 Legal framework for green finance

Recognizing the importance of a legal framework for green finance, Vietnam has taken steps to support action and implementation plans for this area. Specifically, in 2015, the Governor of State Bank of Vietnam (SBV) signed Decision No. 1552/QD-NHNN issuing the Action Plan of the banking sector to implement the National Strategy on Green Growth toward 2020. In addition, the SBV has integrated the green credit program into the legal documents it issues.

The framework for green finance has been gradually forming and the financial system has actively participated in greening the economy. For example, the SBV issued Decision No.1604/QD-NHNN (7 August 2018) approving the Scheme on green bank development. This scheme aims to increase the awareness and social responsibility of the banking system towards environmental protection and climate change, by gradually greening banking operations and directing credit capital into financing environmentally friendly projects. The Green credit program could be a modality to finance the hybrid strategy for Duong Dong.

5.4 User fees and taxation

Both the conventional and hybrid options provide flood protection benefits for people and businesses in the case study area. Residents and visitors from outside the area who use or transit through the area also benefit from improved flood protection. Further, the flood protection and other benefits such as improved amenity and recreational opportunities offered by the hybrid option have both public good (non-rivalrous and non-excludable) and private good (e.g. high property value) elements. A case can be made for funding public good benefits through existing or new broad-based taxes or tariffs. The hybrid option also creates opportunities for revenue streams (e.g. park access charges for tourists and compost sales) for those receiving private benefits from the project and further ease the call on public funds.

A recent study conducted as part of the Work Bank's Phu Quoc Sustainable Water Management Project (SWMP) developed a drainage charge, separate from the environmental protection fee currently collected as part of the water price. The drainage charge aims to recover the costs of operating and maintaining the wastewater management system, reducing dependence on government subsidies. When formally approved and issued, this will reduce the high revenue risk often perceived by private sector in investing in wastewater services.

In designing the drainage charge, policy makers may consider a range of options. A simple fixed amount charged for household, commercial and industrial businesses could reflect the level of benefit received. Alternatively, the charge could reflect capacity to pay (e.g. based on property value) or reflect the 'polluter pays' principle (e.g. a charge based on impervious area). Combinations are also possible (e.g. a minimum charge for all with an additional amount paid for high value properties). A more sophisticated the tariff or tax might be viewed as fairer or more effective in changing undesirable behavior, but it comes with higher implementation and management costs.

5.5 Demonstration projects

Pilot and demonstration projects can demonstrate the value of a particular technology or approach while also ensuring local conditions are reflected in future project analysis and larger scale application. Given systematic application of NbS is relatively new in Vietnam, practical methodologies and tools to quantify the benefits of NbS can be powerful in better understanding costs, risks and benefits and better comparing NbS and conventional approaches. This case study demonstrates and provides an initial estimate of the additional

values of combining gray and green solutions to urban infrastructure investment. Piloting the proposed strategies should be considered to increase the confidence of local government and reduce the cost of funding and financing larger scale applications. As outlined in the next section, in addition to testing new technologies, piloting also provides opportunities to test new business models and forms of public, private and community collaboration.

The *Duong Dong Freshwater Wildlife Conservation Park* generates benefits that align with the vision of Phu Quoc City as an international tourism hub in a way that balances economic growth, sustainability and ecological preservation. It is a high-profile opportunity to demonstrate the value of NbS and leverage technical and financial support from public agencies, the private sector and research institutes.

5.6 Leveraging private investment and public, private and community collaboration

Public finance and funding will continue to play an important role in promoting green growth. The IUFM process also seeks to help bridge the public infrastructure gap by identifying and monetizing additional revenue streams, reducing the need for public funding and increasing financeability and scalability. It also seeks to unlock additional resources and impact through meaningful and effective public, private and community collaboration.

Collaboration across the public, private and community sectors already delivers benefits on Phu Quoc Island relating to plastic waste (Box 1). The hybrid solutions included in this case study provide further collaboration opportunities to reuse organic waste. Additionally, opportunities to position the park as a hub for NbS research may attract research funding while community involvement in maintaining and using the park (e.g. guided tours) and ‘citizen science’ initiatives may also be possible.

Box 1: Examples of collaboration for sustainability already in place on Phu Quoc

In 2018, the World Wide Fund for Nature initiated a 2-year plastic reduction initiative on Phu Quoc Island named 'Phu Quoc – Towards a Plastic Waste Free Island'. The project aimed to improve and protect Phu Quoc's marine environment by 2020, through implementing a public–private partnership to eliminate plastic waste. The initiative was implemented on 4 fronts: (i) policy advocacy; (ii) engagement of private sector, (iii) public awareness; and (iv) community engagement.

In terms of private sector engagement, 40 businesses committed to reducing their plastic footprint, including 20 hospitality and 20 food and beverage businesses. In 2019, a survey of 15 businesses revealed they reduced 9.6 tons of plastic waste, segregated 50 tons of recyclables, and trained 1,900 staff on recommended practices.

Figure 26: Volunteers collect waste at a beach in Duong Dong township for Phu Quoc Environment Day 2020.
Source: VNA.

In terms of community engagement, Phu Quoc City has a pilot model of source segregation for 30 households, collecting 10.6 tons of solid waste (of which 3.1 tons is plastic waste).

A plastic innovation contest was organized to identify and scale entrepreneurial solutions, with 2 finalists for Phu Quoc Island: Phu Quoc Sustainable Farming Club and Fantastic Farm. In 2020, *Phu Quoc Environment Day* included an awareness raising program on the harmful effects of plastic and nylon bags on the economy, environment and human health, solid waste clean-up and tree planting activities, attracting 19,400 participants.

6. Recommendations and next steps

This case study considered the costs and benefits for both the conventional and the hybrid measures, given the flood risk means doing nothing is no longer an option. The chosen path will depend on the priorities of local authorities across many factors including the level of flood protection, ongoing and upfront cost and technical feasibility. The conventional solution will deliver large flood protection benefits overall, but at a much greater cost and without the co-benefits associated with the hybrid solution.

This strategic assessment investigated 2 scenarios. Other combinations and phasing of NbS, hybrid and non-structural solutions are possible and should be investigated. The following recommendations offer some guidance on issues to consider when further investigating the value of hybrid solutions for integrated urban flood and water resources management.

- **Better integrate non-structural measures into the analysis.** This strategic assessment focused on the relative benefits of hybrid NBS and conventional structural solutions. Section 2.1 notes poorly planned urban development, increased impermeable surfaces, encroachment and blockages of natural drainage channels such as Duong Dong River and Ong Tri Creek (from rubbish and inadequate dredging) have disrupted Duong Dong's natural drainage mechanisms. An important aspect of the IUFM approach is to consider both structural and non-structural (e.g. regulation, community engagement, flood water systems and insurance) approaches as part of a balanced *retreat–adapt–defend* flooding strategy.

  Given the lower cost of the hybrid solution, non-structural interventions should be added to assure the effectiveness of the planned measures and increase the effective level of flood protection. The SWMP already includes several non-structural solutions including developing an Integrated Water Resource Management Plan and capacity building in water infrastructure asset management. Evidence-based long term planning and development regulations will also be critical to ensure Phu Quoc's economic growth neither accelerates water cycle challenges nor comes at the expense of community or environmental health and safety.

- **Adopt a water cycle approach.** As an island economy driven by tourism, the quality of the coastal environment is a key natural asset. Kien Giang PPC is currently working with the World Bank to deliver a WWTP in Duong Dong with a capacity of 10,000 m^3/day, about 170.5 km of collection sewers and about 8,000 household connections. However, connecting the WWTP via a combined sewer system will lead to overflows, and undermine protection of the coastal environment. In contrast, a WWTP based on a separated system will reduce required capacity by excluding stormwater. Separating rainwater and wastewater also increases local reuse and recycling opportunities including smaller scale solutions (e.g. rainwater tanks promoted via incentives, regulations and collaboration with hotels and developers) and large scale solutions such as stormwater harvesting and irrigation opportunities identified in this case study.

  MAR – recharging water to aquifers for subsequent recovery, to benefit the environment or mitigate the impacts of groundwater extraction – was not recommended for this site due to the high groundwater table. However, MAR could be used in other locations on Phu Quoc to mitigate unsustainable groundwater extraction

and mounting water demand. It can control saltwater intrusion by maintaining pressure in aquifers, stopping sea and estuary water moving inland and protecting existing bores and good-quality groundwater resources. Water for MAR can be taken from stormwater runoff, recycled graywater or reclaimed treated wastewater.

- **Embed circular economy principles island-wide.** Phu Quoc faces interrelated and urgent challenges with flooding, water supply, water demand, pollution and waste management. This case study attempted to go beyond water management to show how circular economy thinking can apply to both water and waste management and present integrated solutions. On an island-wide scale, Phu Quoc should look at how to minimize imported resources and more efficiently and sustainability use its existing resources. The goal should be a self-sustaining island that promotes inclusive development, the environment and the needs of local communities as well as growth of the tourism sector. Circular economy approaches can present 'win-win' solutions to balance competing needs.

- **Ensure inclusive development.** Disadvantaged communities and households are often more impacted by flooding. While both solutions will reduce the impacts of flooding, the hybrid solution provides additional opportunities for inclusive development including minimized social disruption from resettlement, employment opportunities from the conservation park, and valuable recreational and leisure opportunities. For this reason, although some parts of the park may be designed with entrance fees to generate revenue for cost recovery (e.g. guided tours), it is recommended that the main walkways, recreational opportunities and facilities remain publicly accessible to people with a wide range of needs, backgrounds and abilities.

- **Improve data quality and share insights to inform NbS application across Vietnam.** As noted in Chapter 1, BCAs can be performed for a range of reasons. This high-level strategic assessment illustrated the potential benefits of a hybrid approach and the merits of further investigation to validate the assumptions and results. As well as refining the most appropriate way forward for Phu Quoc, these investigations can inform NbS strategies and assessments on a national level. Two options for improving data quality are: (1) establish an environmental monitoring system across the whole island, particularly a hydrological monitoring system on Duong Dong River; and (2) conduct a flood modelling assignment for Duong Dong catchment based on improved and updated data to determine correctly the extent of flooding risks and potential flooding reduction level of the conventional and hybrid solutions.

The knowledge exchange and sharing of local and international experience and information undertaken as part of developing this case study also highlighted the value of further collaboration in responding to complex urban development challenges with innovative approaches in data-constrained contexts.