

## VIETNAM

## Can Tho, Vietnam

## THE ROLE OF GREEN INFRASTRUCTURE IN MANAGING URBAN FLOODS

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FINDINGS

- Green infrastructure for flood management is a system of linked natural vegetation areas and water bodies, which can be designed, engineered and managed to provide flood retention and runoff buffering services in urban areas.
- Can Tho's central urban district, Ninh Kieu, experiences frequent localized flooding because it is a low-lying, densely developed urban area with a high proportion of impermeable surfaces and a limited drainage system.
- Even in central Can Tho, there are opportunities for green infrastructure to reduce storm runoff and improve the capacity of the drainage system, at much lower cost than installation of new underground sewer pipes, pumps and dikes for this purpose.
- The main opportunities for green infrastructure in Ninh Kieu are:
  - Dredging natural lakes, ponds and existing channels to increase their capacity and improving the vegetative quality of surrounding green spaces to control runoff and serve community and recreational functions;
  - Construction of engineered channels, ponds and lakes in available open space to increase flood retention and water quality;
  - Construction of new multi-purpose public landscapes that can provide open space for recreation in dry conditions, or temporary rainfall retention in heavy rains;
  - Creating levelled seepage landscape areas along sidewalks, parking spaces or courtyards, to increase infiltration and slow surface runoff;
  - Household or building scale rainwater collection and storage.
- Together, these measures could increase the drainage capacity provided by the World Bank drainage system now under construction by over 25%<sup>1</sup>. This would increase its capacity from a 90-

<sup>1</sup> Drainage capacity of the WB project is 1686636 m<sup>3</sup>. Capacity of GI measures (max) is 493,970 m<sup>3</sup>

## KEY FINDINGS

min rainfall event of 81 mm/hr (which is approximately a once in 5 year rainfall event) to a 90 min rainfall event of 95 mm/hr (approx. a one in 20 year event).

- The increased flood management capacity from green infrastructure would reduce property losses, traffic disruption and public health impacts from flooding at low cost, while providing other recreational and environmental amenities to local residents even when no flooding occurs.
- Local governments need to take policy measures to better protect natural drainage, enhance existing water bodies, and encourage innovative landscape design to capture the potential of green infrastructure to reduce flood risks. This will require mechanisms to ensure greater coordination between different technical departments responsible for various aspects of urban development and flood management.

**FIGURE 1.**  
**EXAMPLES OF GREEN INFRASTRUCTURE MEASURES**



Shallow infiltration with grass (Myke, 2018)



Improving water absorption of sidewalks (Truc, 2015)

## Introduction

There is increasing recognition of the potential of natural ecosystems to provide valuable services to urban areas. These ecosystem services may include flood control, water purification, slope stabilization, and erosion prevention. In addition, ecosystems may help to reduce urban temperatures, providing cooling and shade; as well as providing cultural and recreational amenities for nearby urban residents. Economic studies in other countries have shown that services delivered by ecosystems, if they are carefully designed and managed, may cost less than conventional engineering approaches (Atkins 2015; Landscape Institute 2013).

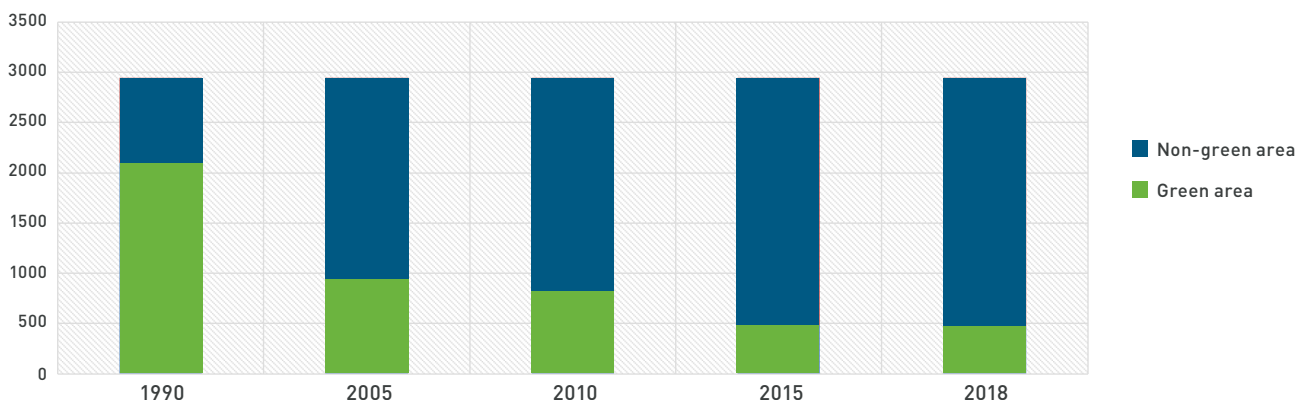
This “green infrastructure” can be defined as a system of linked natural vegetation areas and water channels, ponds, lakes and wetlands, which can be designed, engineered and managed to provide flood retention and runoff buffering services to

reduce flood risk in urban areas (Benedict & McMahon 2012). A study was conducted in Can Tho city’s central Ninh Kieu district to assess the potential value of green infrastructure to reduce the pressure on the city’s drainage system and improve water quality in existing water bodies.

## Brief Description of the Problems

Many cities in Vietnam are located in coastal or river delta areas and are exposed to flooding from upstream areas, local surface runoff, or high tides and storms. Urbanization can lead to increased flood risk. Natural drainage channels and flood retention wetlands are blocked, filled or built over. Ground surfaces are paved or covered with impermeable materials so that heavy rainfall runs off into drains rather than being absorbed into the soil. And increased groundwater extraction can lead to land subsidence in these areas, further complicating drainage.

**FIGURE 2.**  
**CHANGE IN GREEN SURFACE AREA IN NINH KIEU DISTRICT**



Can Tho city, in the centre of the Mekong Delta, experiences flooding from various causes. The entire Mekong Delta is subject to long-term inundation during the rainy season (approximately May – November), when river levels throughout the Mekong river system rise due to heavy upstream rains. At the same time, Can Tho has in recent years been subject to unusual flooding from heavy localized rainfall and from seasonal high tides when river water levels are already high. The causes of flooding in any given context are often complex, and in Can Tho various factors, including land subsidence, high tides, loss of natural drainage channels and poor urban planning have all been implicated as causes of flooding (Tyler, et. al. 2016).

Ninh Kieu district in Can Tho’s urban core is a low-lying area with a dense network of rivers and channels, high population and construction density, and high proportion of impermeable surfaces. Because of these characteristics, localized flooding often occurs after heavy rainfall events. One of the contributing factors is the loss of natural, or green, surface area as the city is developed and various hard surfaces, such as pavement, concrete, or tile roofs, are substituted for natural soils. Heavy rains on these impermeable surfaces will run directly off into drains and rapidly accumulate in low-lying areas, or in slow-moving canals and rivers. In Ninh Kieu district, in the past 50 years almost 95 km of natural drainage channels have been lost, and in the 25 years between 1990 and 2015, over 75% of the green surface area in Ninh Kieu was covered by impermeable surfaces. These changes have clearly contributed to higher surface runoff and localized flooding.

The loss of permeable green surfaces and poor planning of road and drainage infrastructure, together with unplanned encroachment on remaining natural areas have all contributed to this increase of localized flooding during high tides and heavy rains (Tyler, et. al. 2016).

## Addressing the Problems

In 2017 a World Bank project provided loan funds for improvements to the city’s drainage system that will include tidal backflow prevention valves on drainage outlets, to prevent high tide levels in the river from entering the city through existing drainage channels and storm sewers. During brief high tide periods when backflow valves are closed, the system still has some capacity to store runoff until drains can re-open as the tide recedes. The drainage system is expected to significantly reduce flooding, particularly related to high tides, in the central city. However, it may still be insufficient to handle intense rainfall events.

Construction, operation and maintenance of additional infrastructure to manage flooding in the central city, such as underground storm sewer pipes, pumps, tanks and dikes, is extremely costly. They city does not have resources for this kind of investment, or for additional borrowing to pay for it. But green infrastructure offers the potential to contribute effectively to flood management at much lower cost, if there is sufficient land surface available. How feasible would green infrastructure be in Ninh Kieu district in central Can Tho? How much water management capacity might it add to the new

FIGURE 3.

LOCATIONS IN THE CORE URBAN AREA WITH POTENTIALS OF APPLYING GREEN INFRASTRUCTURE MEASURES



**Green areas** have the potential to apply measures to increase the water storage and infiltration capacity.

**Red areas** have the potential to apply measures to increase the infiltration capacity.

drainage system? These were the questions that this study set out to address.

Using remote sensing imagery and field surveys, the study team identified the remaining channels, lakes and ponds; yards and gardens in public facilities; parks, and the roofs of public buildings (which are often quite large). The research revealed a large number of potential green infrastructure sites which could be connected to augment the drainage system, despite the high density of urban development in this district. Potential sites for new or enhanced green infrastructure measures in the central Ninh Kieu district are shown in Figure 3.

The potential for green infrastructure includes five different types of interventions that would each contribute to flood retention, runoff management, or increased infiltration of rainwater within the district. All of these measures would reduce the surface flows and accumulations of water in low-

lying paved surfaces, and would limit or spread out the flow of storm water into the drainage system. In this way, they contribute to absorbing intense rainfall over short periods without requiring either costly and lengthy construction projects, or the capital and energy-intensive addition of large-scale pumping capacity<sup>2</sup>.

<sup>2</sup> Deltares has developed the Adaptation Support Tool (AST) to support the collaborative planning of adaptation measures for a more resilient and attractive environment. This tool provides a range of green infrastructures solutions. There are also many examples of green infrastructure introduced on the website of the US Environment Protection Agency <https://www.epa.gov/green-infrastructure>

1

Dredge and improve existing lakes, ponds and channels to increase their surface water capacity, and manage the green spaces surrounding these water bodies to reduce runoff and soil erosion, increase infiltration and provide high quality public recreational spaces. The idea is to reduce pavement and hard surfaces around these channels and water bodies, creating vegetated surfaces and engineered channels that simulate natural water bodies, yet are carefully designed to allow maximum water retention under heavy rainfall conditions).



Improving river/channel embankment to create space for community recreation activities (Source: climateapp.org)



Improving channels and creating green spaces (Eva & Christoph 2008)

2

Build new flood retention ponds or lakes in existing parks and gardens to moderate run-off and reduce surface water pollution. These new ponds will include vegetation such as native grasses and reeds or aquatic plants that stabilize banks and filter water to remove pollutants. By designing these as “engineered wetlands” linked to the existing

drainage system, they can serve both flood retention and pollution control functions. These features will help to replace the historic natural drainage channels and wetlands that were filled or destroyed in the urban development process.

3

Design and build multi-purpose public recreation facilities with rainwater storage features in existing parks or public areas. During dry conditions these will be accessible public spaces that can have both hard and natural surface areas and may be used for a variety of activities. In heavy rainfall events, they can be designed to capture runoff from surrounding areas and to serve as temporary rainwater storage features, allowing rainfall to be more slowly absorbed into the ground or into the drainage system.



(Source: climateapp.org)

4

Design and build graded seepage surfaces to moderate runoff and allow it to infiltrate into the ground. These surfaces may include new or rebuilt sidewalks or parking areas with permeable surfaces, or small landscape /

vegetation areas along roadways and existing sidewalks. They will be designed to collect and absorb runoff, and will be connected to the drainage system so they can channel or disperse excess runoff safely.

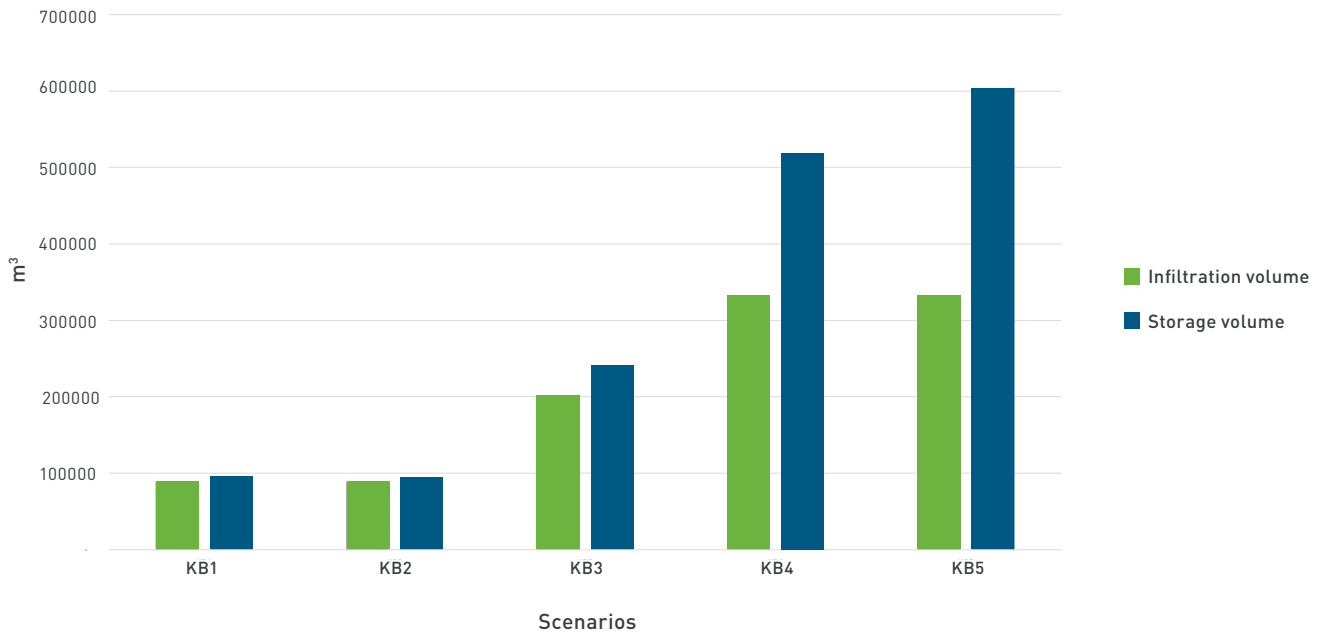
5

Rainwater can be captured and stored at a household scale. Rainwater collection in large storage jars or cisterns is common in the Mekong Delta in areas where surface and groundwater quality is poor. But usually these rainwater harvesting systems are designed for seasonal

storage and domestic use. In urban areas, household systems could be designed for temporary storage of heavy rainfalls, or for seasonal storage for household and garden use during the dry season.

**FIGURE 4.**

**TOTAL AMOUNT OF MANAGED RUNOFF UNDER DIFFERENT GREEN INFRASTRUCTURE SCENARIOS BY 2030**



The study team classified each potential site identified in Ninh Kieu for the application of one or more of these green infrastructure approaches, and then estimated the change in volumetric storage of surface runoff that such development would allow. Of course, surface water storage is only one of the benefits of green infrastructure: it would also provide increased infiltration, and improve the quality of public spaces for recreation and other uses. However, a volumetric storage estimate allows for comparison with the baseline capacity of the existing drainage system, so that residents and decision-makers can easily compare outcomes with the current familiar flood-prone situation. A volumetric storage analysis focuses on the problem of high-intensity rainfall events, where runoff and surface water collection exceed the capacity of the drainage system.

Analysis compared the baseline current situation with the additional drainage capacity provided by the World Bank project, scheduled for completion in 2021. This drainage infrastructure project will create significant additional flood retention capacity even under conditions of high tidal levels in rivers, because of enhancements to dikes, drains and the crucial tidal backflow prevention valves on drains. With these system improvements, the drainage network should be able to handle more than 2.7 times as much runoff as the baseline. But this amount will only ensure flood protection for a 90-minute

rainfall event with a probability of 50% (i.e. one that could be expected every 2 years). A more extreme event, which could become more likely with climate change, would still lead to flooding.

By enhancing existing lakes, ponds and channels in public parks; creating new retention ponds and infiltration systems in these areas; and upgrading existing green spaces, the runoff capacity that can be retained within the district would increase by a further 11%, enough to avoid localized flooding for a 90 minute rainfall event that is so intense it only happens on average once in 5 years.

But with climate change, rainfall intensity may increase, and citizens will demand greater protection of their property as they become wealthier. By developing new retention ponds, channels, and infiltration systems in undeveloped and privately owned lands around the periphery of Ninh Kieu, and by encouraging rainwater harvesting from individual houses and other buildings, surface water retention and runoff reduction could be increased by about 25% over the level expected for the World Bank project (figure 4). These gains would be more costly than just improving existing public spaces, because they would involve removing existing concrete surfaces and acquiring private land, but the results would be a high level of flood protection (extreme rainfall event of one in 20 year



PHOTO: THOI NHUT RESIDENTIAL AREA—PROPOSED PROJECT TO IMPLEMENT GREEN INFRASTRUCTURE APPROACH  
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probability), as well as improved infiltration and groundwater replenishment, better surface water quality, and greater recreational opportunities in the central city.

In summary, green infrastructure measures appear to have the potential to provide significant increases in capacity to the new drainage system currently being built in Ninh Kieu, even though this is a densely developed central city district. This would dramatically reduce flood risks, improve water quality and provide better recreational open space in the central city, all at much less cost than constructing underground drainage systems. However, there are still many challenges in delivering systematic green infrastructure measures in Can Tho.

## Policy issues

Natural drainage channels, lakes and ponds are still under threat of development, despite regulations that nominally protect them, because of the high commercial value of land. Provincial authorities that review development and construction plans do not understand the potential of green infrastructure, and do not currently require impact assessments on runoff and drainage systems for new construction that replaces permeable natural and vegetated surfaces. The

public agencies that are responsible for flood management, flood damage compensation and flood recovery are separate from those regulating construction, urban infrastructure, parks and water quality, so there are few opportunities to analyze, coordinate and integrate the benefits across all these areas of green infrastructure. In particular, mechanisms for coordinated planning, benefit-cost analysis of alternatives, and for monitoring of development outcomes are consistently weak across all government departments. As a result, there is limited awareness of the advantages of green infrastructure, and there are few incentives to adopt these practices when the benefits of one agency's actions reduce costs for another.

Economic development will increase the value of urban land, and the costs of urban flooding. Citizens will demand greater protection and accountability of governments. And climate change will increase sea level and rainfall intensity. The flooding problems in central Can Tho will become a bigger problem, and solutions will become more and more costly for the city's residents. Now is the time to take action. The study team proposes the following policy measures for local action. Measures numbered from 1 – 6 can be undertaken in the short term (2019–2021), while other measures will require longer to fully implement.

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## POLICY MEASURES FOR LOCAL ACTION

- 1 The City People's Committee (CPC) should take leadership on this issue, which crosses the mandates of several different technical departments. As a starting point, direction should be given to the Department of Construction (Doc) to follow up on this study and prepare an inventory of remaining low-lying natural water storage areas and drainage channels in the central city that are being encroached, or are at risk of future encroachment.
- 2 CPC should create mechanisms to strengthen coordination for planning, risk reduction and flood management between relevant technical departments, including (but not limited to): Department of Construction, Department of Natural Resources and Environment (DoNRE), The city Steering Committee for Natural Disaster Prevention and Control, and Department of Agriculture and Rural Development (DARD). Such mechanisms could include clarification of policy goals and contradictory development objectives, greater transparency on key planning regulations and proposed development projects, shared data sets including monitoring information, consultation and review processes, and consistent enforcement processes.
- 3 The Department of Construction should prepare specific regulations for CPC approval to limit urban development in low-lying natural areas with a substantial role in surface water retention, infiltration or flood reduction. Once approved, these regulations should be vigorously enforced, despite the commercial pressure for development. Monitoring of encroachment and illegal filling of these areas should include the participation of local communities.
- 4 DoC and DoNRE should jointly survey and identify natural drainage channels and canals in the central city that have been encroached or filled, and prepare recommendations on the feasibility of restoring these channels.
- 5 DoC should review, adjust and update construction elevation regulations to ensure they remain relevant in view of climate change and urban development context, and changing flood risk.
- 6 Combined hydraulic / hydrological flood models should be developed and regularly updated to support urban planning, drainage and infrastructure planning, transportation planning and the appraisal and review of relevant construction and infrastructure projects under the authority of DoC, DARD, and Department of Construction.
- 7 The city should encourage and support pilot innovative green infrastructure models to support drainage and flood risk reduction, for example rainwater harvesting models; and flood reduction along the Ngong channel in Thoi Nhut resettlement area, An Khanh ward.
- 8 DoNRE should develop tools for monitoring spatial changes in green and blue surfaces and provide regular reports to CPC (at least annually, perhaps even semi-annually).
- 9 DoC should develop a plan to integrate green infrastructure measures into the upgrading and renewal of public spaces in the central city, such as plazas, parks, ponds and lawns, to reduce runoff, increase surface water storage and infiltration, and improve water quality.
- 10 CPC should authorize and approve a city-wide green infrastructure plan that will describe appropriate general measures for different districts depending on their degree of development and flood risk levels, together with broad guidelines and monitoring mechanisms to ensure the strategy is implemented by the responsible authorities at the departmental level and at the district level.

## National Policy Issues

There are many national policies in support of climate adaptation, flood risk reduction, green growth and improved urban planning that takes these factors into consideration. However, implementation of these policies has been inconsistent and fragmentary at the local level because they all require better coordination between different technical departments, which is difficult in the Vietnamese planning system. The key to better local coordination, however, is not

greater authority for any one department, but better tools and mechanisms for collaboration, clearer management guidance on goals and specific related development objectives, and better mechanisms for review of plans and development projects both within and between departments to ensure that they are consistent with policy goals and development objectives.

In relation to green infrastructure in particular, the following national policy measures would be helpful to cities like Can Tho that face risks from flooding or other climate hazards:

### HELPFUL NATIONAL POLICY MEASURES

- 1 The Ministry of Natural Resource and Environment should prepare guidelines for how to assess the impacts of urban development projects on localized drainage and flooding. This type of assessment should be required as part of project Environmental Impact Assessment and Strategic Environmental Assessments for any large-scale urban development project. These assessments should suggest mitigation and design measures that will increase surface water retention and infiltration, and reduce runoff.
- 2 The Ministry of Construction should provide guidance for local regulations to prevent encroachment on existing canals and drainage channels in urban areas, including tools for monitoring such encroachment using remote sensing or drone surveys. Training in enforcement mechanisms and legal tools should be provided. Policies and national regulation in support of these measures may be required.
- 3 Guidance documents should be prepared by MoC and MoNRE for construction planning at various scales, from the urban master plan down to the site level, on how to reduce runoff and enhance water retention, infiltration and natural drainage through green infrastructure engineering and landscape design measures. These documents could be prepared in collaboration with national experts and research institutions, and based on emerging local pilots and international experience.
- 4 Based on pilot experience and expert advice, MoC should develop guidelines and institutionalize regulations for the integration of green infrastructure into urban plans, construction plans, site plans, infrastructure plans and drainage plans. These guidelines should provide for local variation depending on topography and climate conditions, and include guidance on procedures for review, inspection and enforcement at the local level.

In addition to these national policy measures, the government should provide support for research activities by national experts to design, test, monitor and evaluate pilot projects for urban green infrastructure, and ensure that results are rigorously reviewed and then disseminated to cities throughout Viet Nam. Professional associations for engineering, water management and urban planning should ensure that their

members are well informed about the potential and risks of green infrastructure, and should support critical review of experience and shared learning to build consensus on good practices. This could be an area of engagement for the Urban Climate Resilience Community of Practice and its membership.

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