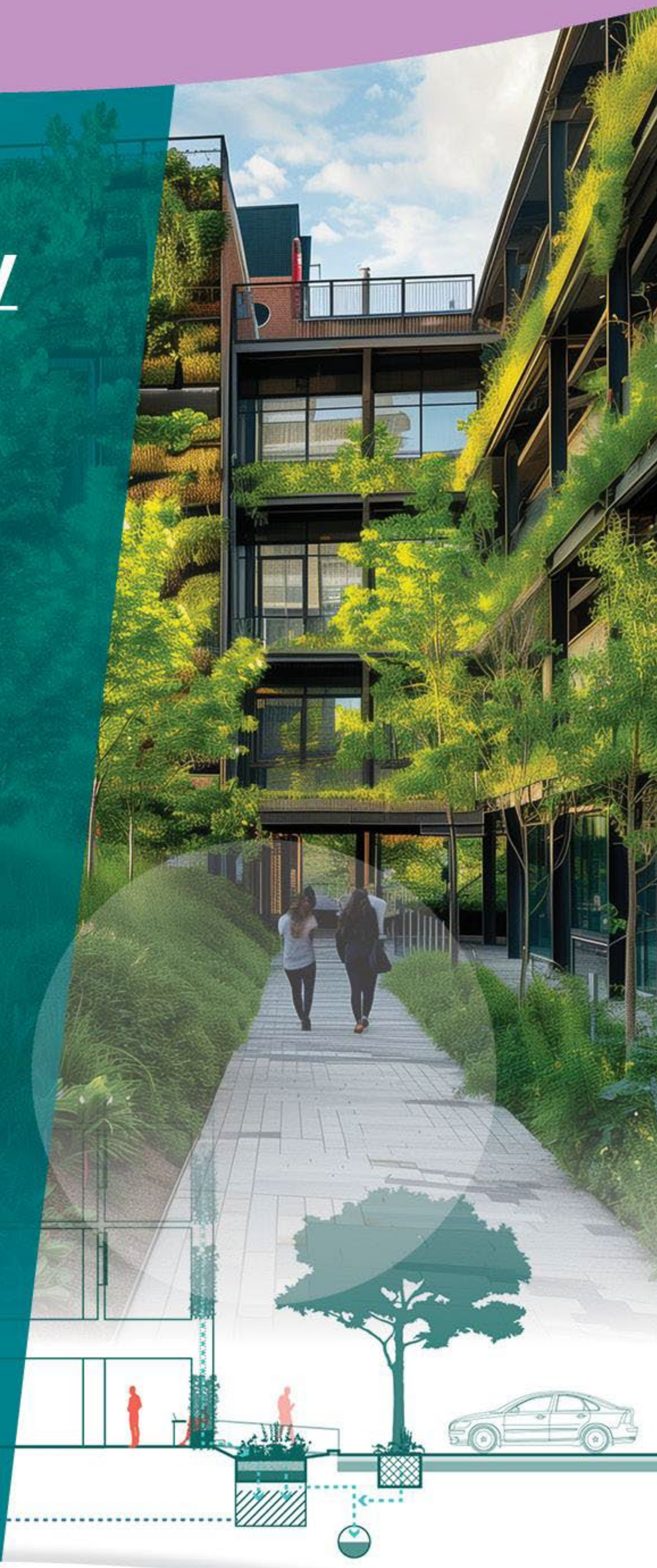
RESILIENT URBAN CENTRES AND SURROUNDS

Hanoi University of Civil Engineering

Hanoi, Viet Nam

CASE STUDY REPORT



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Hanoi University of Civil Engineering – Hanoi, Viet Nam
Case Study Report

Prepared by WSCA and ICEM

Prepared for DFAT

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Disclaimer

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Abbreviations

BCA	benefit–cost analysis
BCR	benefit–cost ratio
GEDSI	gender equality, disability and social inclusion
HUCE	Hanoi University of Civil Engineering
ICEM	International Centre for Environmental Management
NbS	nature-based solutions
NPV	net present value
RUCaS	Resilient Urban Centres and Surrounds
WSCA	Water Sensitive Cities Australia

Executive summary

THE VISION FOR HANOI UNIVERSITY OF CIVIL ENGINEERING (HUCE) IS TO MODEL HOW NATURE-BASED SOLUTIONS (NBS) CAN IMPROVE FUNCTIONING OF EXISTING INFRASTRUCTURE, AND DELIVER IMPROVED OUTCOMES RESPONDING TO HEAT, WATER MANAGEMENT AND ACCESSIBILITY TO A HEAVILY BUILT UP AREA ON CAMPUS.

Case study context

The HUCE campus largely comprises 5–6 storey medium height buildings, similar to other buildings and houses in the compact inner areas of large Vietnamese cities. Buildings such as these can create problems:

- They contribute to urban heat because:
    - being surrounded by other high-rise buildings reduces ventilation
    - building materials trap heat
    - heat reflects off concrete yards and car parks, and there is limited shade trees or green space.
- Poor drainage and non-functioning (or non-existent) rainwater systems lead to ponding during heavy precipitation events.
- Buildings do not comply with current accessibility codes.

Generally, classrooms hold 50–150 students, yet are only ventilated by fans during extremely hot weather (with temperatures of up to 40^{o}C).

Figure SEQ Figure * ARABIC 1: Location of HUCE

Source: RUCAS project team.

Range of options considered

RUCaS is working with HUCE to incorporate NbS at a building scale that respond to urban heat, poor water management and amenity. NbS have been applied in Viet Nam for many years, offering opportunities to manage rapid population growth and climate change at scale. This case study is intended to demonstrate the range of ideas and measures that can be implemented in one location.

In particular, it explores options to extend use of NbS being developed at a smaller scale elsewhere on the campus – green walls, planting boxes, rainwater harvesting, green energy and accessible design – into a more common context of multi-storied high-rise teaching buildings. These interventions aim to reduce heat, generate fit-for-purpose water supplies, provide shade and cooling, and improve accessibility. They can be implemented together or individually, to assess specific issues. Sensors can also be used to monitor and evaluate the performance of the interventions across the campus, supporting teaching modules to incorporate nature-based and accessible design solutions.

Embedding NbS in the campus of a design, engineering and architecture school also aims to help nurture future champions.

Valuing benefits and costs and comparing results

The benefit–cost analysis (BCA) results for HUCE are presented below:

- The benefits of the project exceed the costs, generating a net present value of $US 573,488 (i.e. the present value of benefits less the present value of costs). Put another way, every $US 1 of costs was found to generate $US 3.40 in benefits (i.e. benefit–cost ratio (BCR) of 3.4).
- The project generates benefits with a present value of around $US 810,000 largely in the form reduced urban heat benefits (55%), followed by improved amenity benefits (32%). HUCE students are the major beneficiaries (accounting for 81% of all benefits).
- The estimated present value of costs was around $US 197,000, with HUCE assumed to bear all direct costs. The costs associated with installing the porous paving accounted for the largest share (55%), followed by the bioretention planters (18%) and the solar energy system (13%). Initial construction costs accounted for around half of all costs, with ongoing maintenance and replacement costs accounting for the other half.
- Sensitivity testing revealed the following results:
  - The benefits remained greater than the costs for the range of discount rates tested (2–6%).
  - All costs and benefit estimates were varied by +/-30%, and estimates applied across 1,000 different combinations. This testing suggested benefits would outweigh the costs in all scenarios, with the most likely outcome of a BCR between 2.0 and 3.7.
- Before implementation, the following factors need further investigation:
  - broader community consultation on concept designs
  - a survey of HUCE students and staff and surrounding businesses to understand their views on benefits
  - refinement of costs ideally through a project pilot.

Funding and financing

HUCE has 3 sources of revenue: state budget funding, tuition revenue and revenue from service activities. It seeks to self-finance operations, which means it requires additional funding sources.

The HUCE H1 NbS retrofitting fits Resolution of the 2020 Congress of Delegates (term 2020–2025) of the Hanoi City Party Committee to rapidly and sustainably develop the capital into green urban areas and a smart, modern city by 2030. By 2045, Hanoi aims to become a fully green, smart and modern city, achieving comprehensive and sustainable development. The Resolution emphasises that creating a ‘green urban area’ is the first step in Hanoi's journey toward becoming a ‘green city’ with sustainable development.

The HUCE case study calls for mobilising resources from the state budget, private investments and non-government organisations to implement green growth initiatives.

The approach for funding and financing NbS for the HUCE H1 NbS retrofitting comprises the following elements:

Balancing centralised and decentralised financial solutions

A mix of centralised and decentralised financial solutions may be used to finance climate change initiatives, particularly solutions that involve citizens at the grassroots level. Various financing instruments – such as public fiscal transfers, green bonds and public–private partnerships – may be available, depending on project type and sponsor.

The approach for HUCE highlights the value of decentralised initiatives and community participation in reducing overall project costs.

Leveraging private investment and social capital

Public finance will remain vital in promoting green growth, but leveraging private investment can help bridge the infrastructure funding gap. Inclusive and universal design incorporating NbS to improve building and campus amenity can contribute to increased student enrolment, presenting potential for capital recovery and revenue generation.

Private sector investment in NbS projects can be encouraged through incentives like tax exemptions and value added tax (VAT) exemptions for green projects. Vietnamese banks offer green credit packages with preferential conditions, contributing to the growth of green financing. Public–private partnerships and the green financial market, including green bonds and the Viet Nam Sustainable Development Index, are essential for mobilising resources.

Taking advantage of a growing green finance system

Viet Nam needs significant investment for sustainable development, with half of the required funding expected from the private sector. International investment funds are ready to invest substantially in green projects, but Viet Nam must prepare to attract this capital. Innovative financial tools, such as green bonds and climate-smart capital, are crucial to addressing resource gaps for green growth and climate resilience.

Upscaling

The following opportunities and barriers may affect implementation of the proposed approach at HUCE and use of NbS throughout Viet Nam more broadly:

- National and provincial policies support NbS but lack detailed guidelines for practical implementation.
- GEDSI (gender equality, disability and social inclusion) considerations need more explicit integration.
- Existing laws generally support NbS, but the absence of technical standards complicates execution.
- Community engagement practices are required by law but may not be consistently applied; however, involving students and teachers through competitions has shown promise.
- Funding for the project requires a strategic approach, incorporating various sources, while capacity building is needed to construct and operate hybrid NbS options.

Methodology

This case study is one of 8 being developed by the Resilient Urban Centres and Surrounds (RUCaS) program. Each case study follows the same 5-step process summarised below (also see Appendix 1).

Figure 2: Integrated Urban Climate Management framework

Source: RUCaS project team.

1. Define your urban content

The site for this case study is the H1 building complex at HUCE's main campus at 55 Giai Phong, Dong Tam Ward, Hai Ba Trung District, Hanoi, Viet Nam.

Social, economic and environmental considerations

Hanoi

Viet Nam's capital Hanoi is the country's second largest city, with almost 9 million residents[1]. Along with the growing economy and population, the city experiences increasing air pollution, urban heat, lack of green spaces, flooding and water pollution.

Hanoi was ranked as the second most polluted city in south east Asia in 2019 by IQAir AirVisual.[2] Every year, 32% of deaths (5,800 deaths) are related to air pollution, and healthcare costs related to air pollution represent 7.7% of Hanoi's Gross Regional Domestic Product (GRDP).[3]

In 2019, the city experienced Viet Nam's second-highest recorded temperature (42°C) since 1957.[4] Heat can significantly affect human health and productivity, especially vulnerable population groups. The resulting productivity loss may be as much as 5% by 2030 either because it is too hot to work or because workers have to work at a slower pace.[5]

Rising temperatures largely reflect the city's urbanisation and reduced green spaces. The expansion of hard surfaces (rooftops, roads, pavements) causes urban heat islands where rooftop and paved areas absorb and then release solar energy and heat waste from motorised vehicles. Over the past 12 years, Hanoi's total urban heat island area tripled (from 3.1% to 9.4%)[6], and green space represents only 2 m^2/person (one-tenth of the green space available in developed cities).[7] One study showed areas with reduced green space were more than 4°C hotter.[8]

Further, urban heat will likely remain an issue given Hanoi's aim to reach 75% of urbanisation by 2030.[9] To address this issue, Politburo Conclusion No. 80-KL/TW emphasises increasing green spaces, green transportation and sustainable urban models for Hanoi. However, restoring or creating green spaces is challenging due to the decreasing availability of vacant land and high land prices in the city centre, coupled with the pressure for land development and the lack of long-term planning.[10]

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[1] General Statistics Office (2022). *Statistical Year Book of Viet Nam 2022*. Hanoi.

[2] Recorded PM2.5 was 4–5 times above the recommended average levels of 10 micrograms suggested by the World Health Organization. IQAir (nd). *Air quality in Hanoi*.

[3] World Bank and Hanoi Department of Natural Resources and Environment (2021). *Air Quality In Hanoi: Current Situation and Policy Intervention*. World Bank: Hanoi.

[4] Ministry of Natural Resources and Environment (2020). *Status of National Environment in 2016 – 2020*. Hanoi: MONRE.

[5] International Labour Office (2019). *Working on a WARMER planet: The effect of heat stress on productivity and decent work*. Geneva: ILO.

[6] Nguyen Thi Thuy Hanh and Quach Thi Chuc (2022). 'Utilizing Landsat Imageries to Monitor Urban Heat Islands In Hanoi, Vietnam from 2009 to 2021', *Science On Natural Resources And Environment*, 43: 48–59.

[7] Ngoc Mai (2022). 'Long-term vision in planning required for more green urban space in Vietnam', *Hanoi Times*.

[8] MT Le, TAT Cao and NAQ Tran (2019). 'The role of green space in the urbanization of Hanoi city', *E3S Web of Conferences*, 97: 01013.

[9] Ministry of Construction (2024). *Hanoi strives to raise urbanisation rate to 75% by 2030*. Hanoi: MOC.

[10] Ngoc Mai (2022). 'Long-term vision in planning required for more green urban space in Vietnam', *Hanoi Times*.

Despite planning for green spaces in Hanoi since 2014 under Decision No. 1495/QD-UBND, only about one-third of the goals have been achieved. To date, Hanoi has completed 9 of 25 planned parks and 400 ha of green areas (of a target of 947 ha).

Hanoi also experiences flooding and water pollution, with 30 areas prone to flooding when it rains, causing traffic congestion and disruption for residents.[11] Hanoi is addressing the problem using grey infrastructure such as underground reservoirs and upgraded drainage systems. The city acknowledges these as a temporary solution to reduce localised flooding but notes they are not a long-term fix.

Hanoi University of Civil Engineering (HUCE)

Established in 1966, HUCE offers undergraduate and graduate programs in civil engineering, architecture, environmental engineering and urban planning. It is recognised for its rigorous academic standards, cutting-edge research and strong ties with industry and government. It plays a crucial role in advancing engineering education and providing innovative solutions to infrastructure challenges. The university also engages in various research projects, often focusing on sustainable development, urban infrastructure and technological advancements in civil engineering.

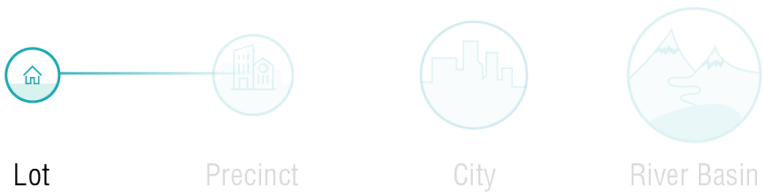
Figure 3*: *HUCE campus

Source: Google Images.

The campus comprises various urban typologies, ranging from old one-storey classrooms from the 1980s (C4 area) to 10-storey modern buildings, on-ground and underground car parks and a canteen. It is next to the Hanoi Polytechnic University and dense residential areas.

SPACIAL SCALE

The area at Hanoi University, within the Dong Da District, is classified as lot scale for the application of nature-based solutions (NbS).



[11] Ngoc Mai (2024). '[Hanoi steps up efforts to address flooding]', *Hanoi Times*.

Figure 4: Satellite image of HUCE

Source: Google Images.

Low- to medium-rise buildings (3–5 stories) are very common throughout Viet Nam. To demonstrate the benefits of applying NbS to this dominant building type, this case study focuses on Building H1. This 6-storey building covers 0.4 ha, including the parking area. The long edge of the building faces west while the main building entrances face south.

Figure 5: Building H1 site

Source: RUCaS project team.

The site attracts around 22,000 undergraduate students, almost 2,100 post-graduate students and around 1,000 faculty and staff to study, research, teach and work.[12] Most classrooms host 50–150 students, ventilated only with fans during extremely hot summers (with temperatures of up to 40^{o}C).

[12] HUCE (2023), personal communication.

Despite the limited use of air conditioning, energy costs are VND 10 billion (USD $405,000) annually.[13]

Figure 6: Typical classroom in H1
Source: RUCaS project team.

Planter boxes on the south side are passively irrigated via rainwater downpipes that discharge runoff from the roof directly to the ground. The water flows through spaces between the planters into the covered drainage system (Figure 7).

[13] HUCE (2023), personal communication.

Figure 7: H1 west and south orientations

Source: RUCaS project team.

The main problems with these buildings and related urban areas in main cities in Vietnam are:

- urban heat caused by (i) lack of ventilation due to being surrounded by high-rise buildings, (ii) building materials trapping heat, and (iii) heat reflection from the concrete yards and car parks
- ponding during heavy precipitation events due to poor drainage
- poor accessibility because the building is accessed by steps; there is no ramp.

Climate risks and vulnerability

Viet Nam faces high disaster risk levels (ranked 91 out of 191 countries), reflecting its high exposure to flooding, tropical cyclones and drought:[14]

- The country has extremely high exposure to flooding (ranked joint first with Bangladesh), including riverine, flash and coastal flooding. It also has high exposure to tropical cyclones and their associated hazards (ranked 8th).
- Low-lying coastal and river delta regions are very vulnerable to sea level rise and storm surges. Projections suggest 6–12 million people could be affected by coastal flooding by the end of the century.
- Drought risk is lower, although still significant, as highlighted by the severe drought of 2015–2017.
- Temperatures are projected to increase by 1–3.4°C by the end of the century. Temperature rises in what is already a hot country are expected to cause chronic heat stress in some areas, particularly affecting poorer communities.

Climate change models forecast annual rainfall increases in Hanoi of 12–14% in the 2050s and 18–23% in the 2100s (Figure 8). Hanoi is also expected to become hotter. The city's annual average air temperature rose from 23.4°C in 1980 to 24.8°C in 2010.[15] It is expected to rise again by 2.1°C by the 2030s, with 1.5°C and 0.6°C attributable to global warming and land use changes, respectively. These temperature forecasts are expected to continue, rising by 1.7–2.2ºC by the 2050s and 2.3–4.1ºC by the 2100s (Figure 9).[16] The future increase in urban temperature will likely exceed the cooling effects of any urban heat island (UHI) mitigation measures.[17]

[14] World Bank and Asian Development Bank (2021). *Climate risk country profile – Viet Nam*. Bangkok: World Bank.

[15] Vietnam Green Building Council (2015). *The Urban Heat Island Effect*. Hanoi: VGBC.

[16] ICEM estimates (2022).

[17] AR Trihamdani, HS Lee, T Kubota and S Iizuka (2018). 'Urban Climate Challenges in Hanoi: Urban Heat Islands and Global Warming', in T Kubota, HB Rijal and H Takguchi (eds) (2018). *Sustainable Houses and Living in the Hot-Humid Climates of Asia*. Singapore: Springer, 529–539.

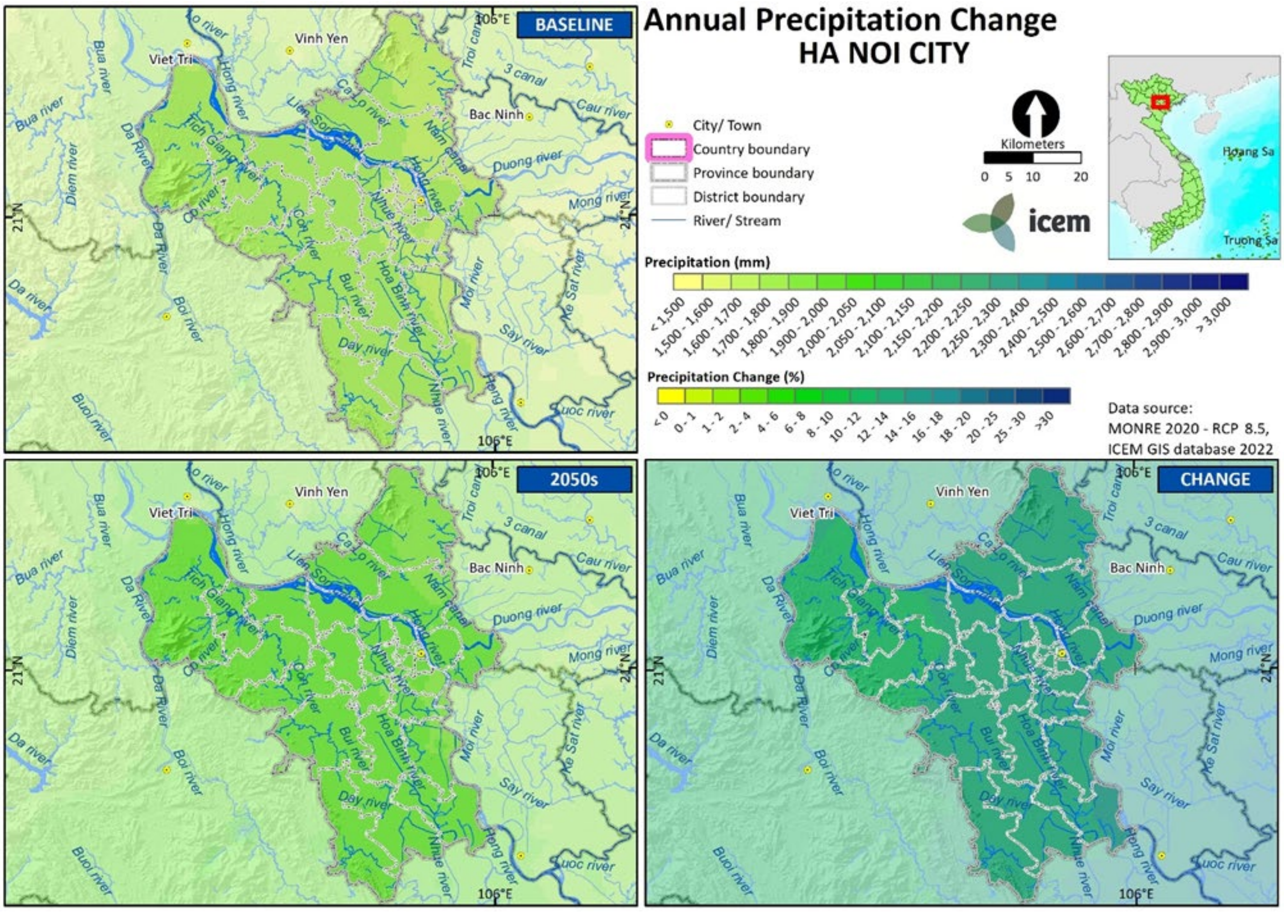


Figure 8: Projected annual precipitation changes in Hanoi City by 2050s under RCP8.5

Source: ICEM.

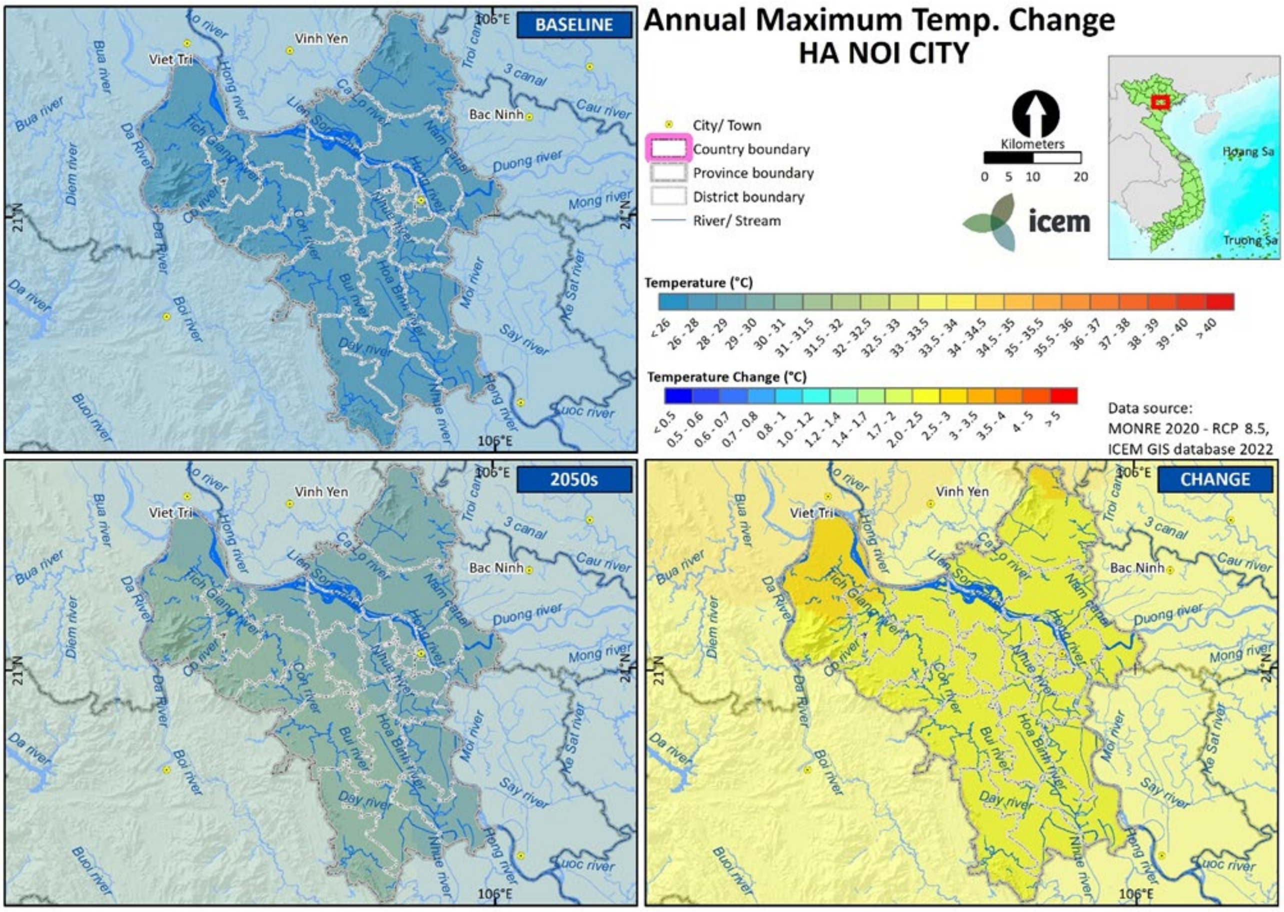


Figure 9: Projected annual daily maximum temperature changes in Hanoi City by 2050s under RCP8.5

Source: ICEM.

Residents in built up areas are particularly vulnerable to these extreme temperatures, because of urban heat islands. Indeed, the average land surface temperature of built-up areas is approximately 3°C higher than in green areas.[18] These events make expanding green spaces that incorporate tree canopy cover and healthy water bodies a priority. High temperature areas need immediate mitigation, such as increasing green space and implementing vertical gardens.[19]

Urban heat directly affects human health by creating heat waves and heat stress, and spreading vector-borne diseases. Higher temperatures can also cause heightened acute and chronic exposure to air pollutants and reduced physical health and wellbeing.[20]

The impacts of climate change are often most acutely felt by vulnerable groups including women, people living informally and those with a disability. These groups often experience an intersectional vulnerability in terms of being susceptible to increased heat events and other extreme weather events – often marginalised from services and unable to access positive green urban spaces, and with less capacity and resources to adapt and respond. Further those who live in informal settlements or who are from low-income households can often face disproportionate exposure to disasters, contamination sources and pollution. Women and girls account for a higher number of deaths due to diarrheal diseases and higher disability adjusted life years caused by inadequate hygiene.[21] The greatest

[18] RC Estoque, Y Murayama and SW Myint (2017). 'Effects of landscape composition and patter on land surface temperature: An urban heat island study in the megacities of Southeast Asia'. *Science of The Total Environment*, 577: 349–359.

[19] P Iamtrakul, A Padon and S Chayphong (2024). 'Quantifying the impact of urban growth on surface heat islands in the Bangkok Metropolitan Region, Thailand'. *Atmosphere*, 15(1): 100.

[20] SD Arifwidodo and T Tanaka (2105). 'The characteristics of urban heat island in Bangkok, Thailand'. *Procedia – Social and Behavioral Sciences*, 195: 423–428.

[21] A Prüss-Ustün et al. (2014). 'Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: a retrospective analysis of data from 145 countries', *Tropical Medicine and International Health*, 19(8), 894–905.

burden of water-borne diseases also fall on children under 5 years of age.[22] People with disabilities and older people may have less resilient health, increasing the risk of illness or premature death caused by contaminated water. [23]

The traffic conditions – including poor surface maintenance of both roads and pavements, encroachment of pedestrians and bicycle lanes by hawkers and street vendors, and an overall hostile transport environment for cyclists and pedestrians dominated by private cars and motorcycles – make getting around the city to access green spaces more challenging and less safe for children, elderly people and people with disabilities. People with mobility disabilities in general also visit green spaces much less frequently than the able-bodied population.[24] Studies show visits to parks depend on proximity. Further, people who visited parks were more likely to exercise regularly, gaining physical and mental health benefits.[25]

Parks in urban areas are important as biodiversity hotspots in cities, connecting people with nature and providing important ecosystem services such as pollination by native insects, and providing food for humans and other animals.[26] Exposure to nature provides mental and physical health benefits and creates an understanding of the value of the natural world. A study across 9 megacities in east and south east Asia, found that frequent visits to natural places in urban neighbourhoods was associated with increased familiarity with urban wildlife (such as caterpillars and butterflies), and increased connectedness to nature.[27] For those in urban areas, the nature they interact with is usually in parks, however, their unequal distribution based on socioeconomics, means many city dwellers are under-served, raising questions of social justice.

A range of measures are proven to enhance urban biodiversity. These include expanding natural habitats, strengthening connectivity, rewilding the urban matrix, planting native species, protecting Key Biodiversity Areas, and adopting wildlife-friendly management practices. Fostering compact integrated development, conducive to 'liveable density', can help to curb urban sprawl thereby averting the loss of hinterland habitat. Land use planning and zoning can help to steer unavoidable urbanisation well clear of critical natural assets while biodiversity credit or offsetting schemes can help to exact net gains from development projects.[28]

[22] DR Boyd (2021). *Human rights and the global water crisis: water pollution, water scarcity and water-related disasters*. Report of the Special Rapporteur on the issue of human rights obligations relating to the enjoyment of a safe, clean, healthy and sustainable environment. New York: UN OHCHR.

[23] DR Boyd (2021). *Human rights and the global water crisis: water pollution, water scarcity and water-related disasters*. Report of the Special Rapporteur on the issue of human rights obligations relating to the enjoyment of a safe, clean, healthy and sustainable environment. New York: UN OHCHR.

[24] UK Stigsdotter, SS Corazon and O Ekholm (2017). 'A Nationwide Danish Survey on the Use of Green Spaces by People with Mobility Disabilities', *Scandinavian Journal of Public Health,* 46(6): 597–605.

[25] S Miao, N Sasaki, TW Tsusaka and E Winijkul (2023). 'Park-Based Physical Activity, Users' Socioeconomic Profiles, and Parks' Characteristics: Empirical Evidence from Bangkok', *Sustainability*: 15(3):2007.

[26] APN-GCR (2024). *Urban biodiversity and human wellbeing in Asia's megacities*. Kobe: APN-GCR.

[27] VC Lim et al. (2022). 'Familiarity with, perceptions of and attitudes toward butterflies of urban park users in megacities across East and Southeast Asia'. *Royal Society Open Science*, 9(11): 220161.

[28] IUCN (2021). *Cities and nature: the issues*. Gland: IUCN.

2. Consider a full range of options

This case study compares the benefits and costs of implementing the NbS concept (Option A) in the H1 building to the do-nothing scenario (baseline).

Baseline: Business as usual

This option assumes:

- no retrofitting to the building or parking plaza area, which will continue to experience heat during summer
- no changes to rainwater and stormwater management on site, so ponding will continue during and after rain events
- no changes to vegetation and landscaping amenity around the building, so heat and water use will continue as usual
- access to buildings and amenities will remain poor, limiting opportunities for peoples with disabilities, and for women and girls to access women-friendly facilities.

Option A: Retrofit with NbS

Create

Introduce NbS options onto existing buildings and plaza

The limited availability of vacant land, high land prices and competing land uses for economic growth pose challenges in implementing large-scale NbS. A study on the urban heat island effect in Hanoi found that smaller, well-distributed green areas were more effective in mitigating heat compared with large, centralised green spaces.[29] This finding indicates that introducing NbS in small spaces or retrofitting existing buildings with plot-scale NbS, such as raingardens, green roofs, permeable surfaces and bioretention swales, may be a viable approach given the land constraints.

Our proposed option aims to address heat and ponding issues using water sensitive urban design (WSUD) principles and NbS. Some interventions will be included specifically to improve gender equality, disability and social inclusion (GEDSI) outcomes:

- Universal design principles will improve accessibility for people with disabilities and support compliance with building regulations. This is meaningful for students with disabilities as the number of people able to read and write between 16 and 24 years old accounted for nearly 70% of the group, but only 0.1% of Vietnamese people with disabilities attended colleges or universities.[30]
- Feminist sensitive design will create safe and welcoming spaces for women and men, in particular by helping to improve access and use of facilities for women and female students.

The proposed interventions are presented in Figure 10 and outlined below.

Ownership of the site will be necessary to ensure stakeholders, mainly the HUCE students, maximise its use and commit to its upkeep.

Heat interventions:

- Retrofit solar shading structures on the building.
- Retain and increase tree numbers.
- Paint the roof a light colour to reflect heat, and cover a large tract with solar panels.
- Install green walls and a green façade for cooling.
- Expand bioretention planters and rain gardens, extending cooler areas close to classrooms and corridors.
- Add waterbody infrastructure for cooling, treatment, storage and amenity for H1 and the wider campus.
- Replace the concrete yard in car park with green porous pavement, reducing heat reflection.

Water retention interventions:

- Replace the concrete yard with porous pavement to increase infiltration.

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[29] AR Trihamdani, NH Tung, T Kubota, HS Lee and TTT Phuong (2015). 'Urban heat islands in the future Hanoi City: Impacts on indoor thermal comfort and cooling load in residential buildings', *ICUC9 – 9th International Conference on Urban Climate jointly with 12th Symposium on the Urban Environment*, 20–24 July, Toulouse, France.

[30] Seminar on education access for disabled students held by the Disability Research and Capacity Development (DRD) centre in October 2023 in Ho Chi Minh City.

- Lower existing planters and convert them to bioretention planters to infiltrate water from the yard.
- Connect the rainwater downpipe to bioretention planters.
- Harvest and reuse rainwater for toilet flushing.

Accessibility and amenity interventions:

- Improve access to H1, aligning with compliance standards for access for people with mobility and sight impairments under the Vietnamese code.
- Retrofit toilets, increasing accessibility for peoples with disability and women as target groups, and to use harvested rainwater for flushing.

Other inventions that may be considered in future relate to monitoring and education:

- Sensors can be applied to these initiatives. An initiative involving HUCE management, students and RUCaS is being considered to design a package of sensors that measure changes in heat, water use and water savings. If implemented, sensors will measure interventions at this site along with other sites on campus as controls, or where other NbS interventions are being developed, such as the C4 site.
- Smart systems to control water and lighting could also be considered.

Hanoi University of Civil Engineering

Hanoi, Viet Nam

Vision Statement:

The vision for Hanoi University of Civil Engineering (HUCE) is to model how nature-based solutions (NbS) can improve functioning of existing infrastructure, and deliver improved outcomes responding to heat, water management and accessibility to a heavily built up area on campus.

Resilience Strategy – cross section

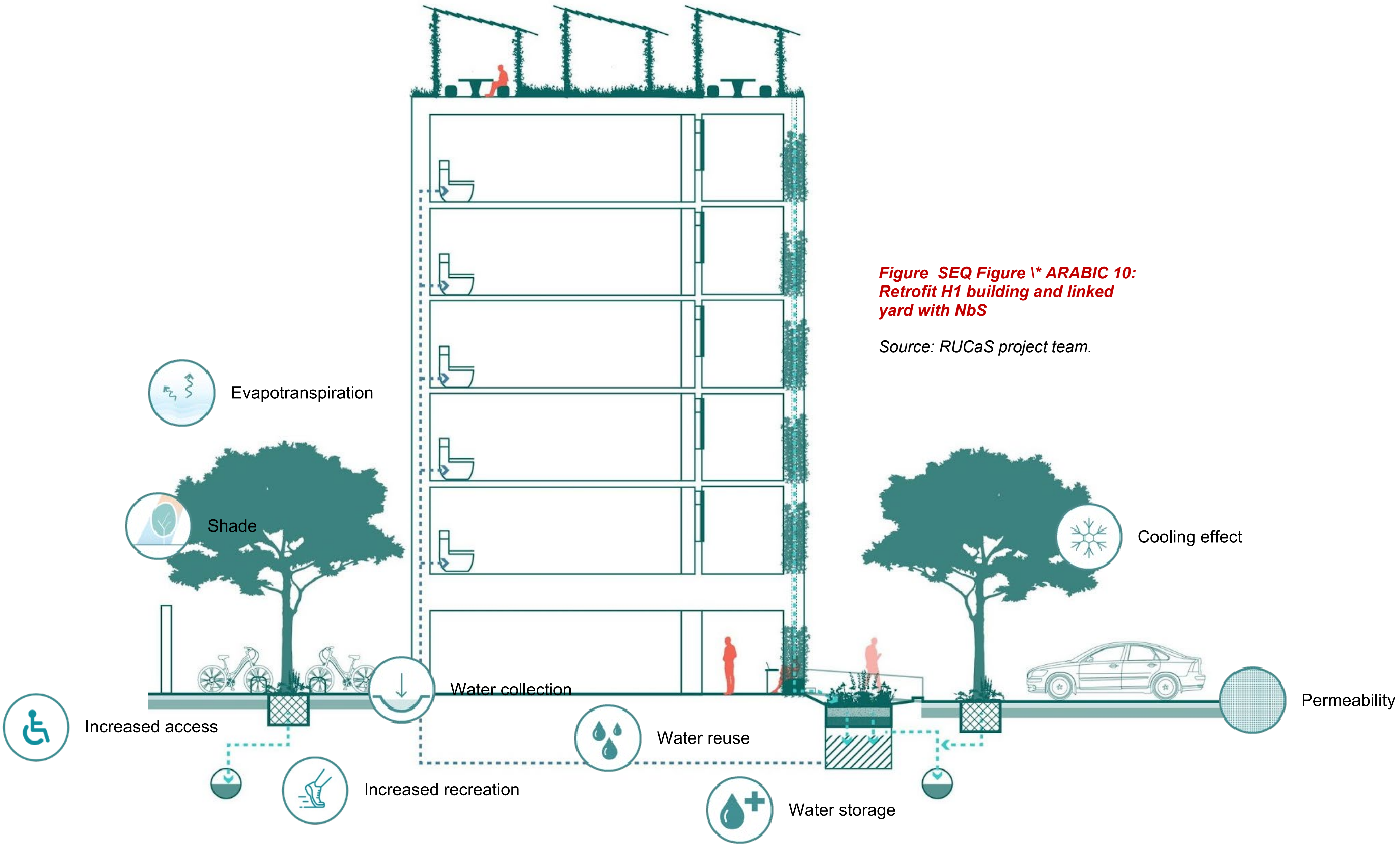
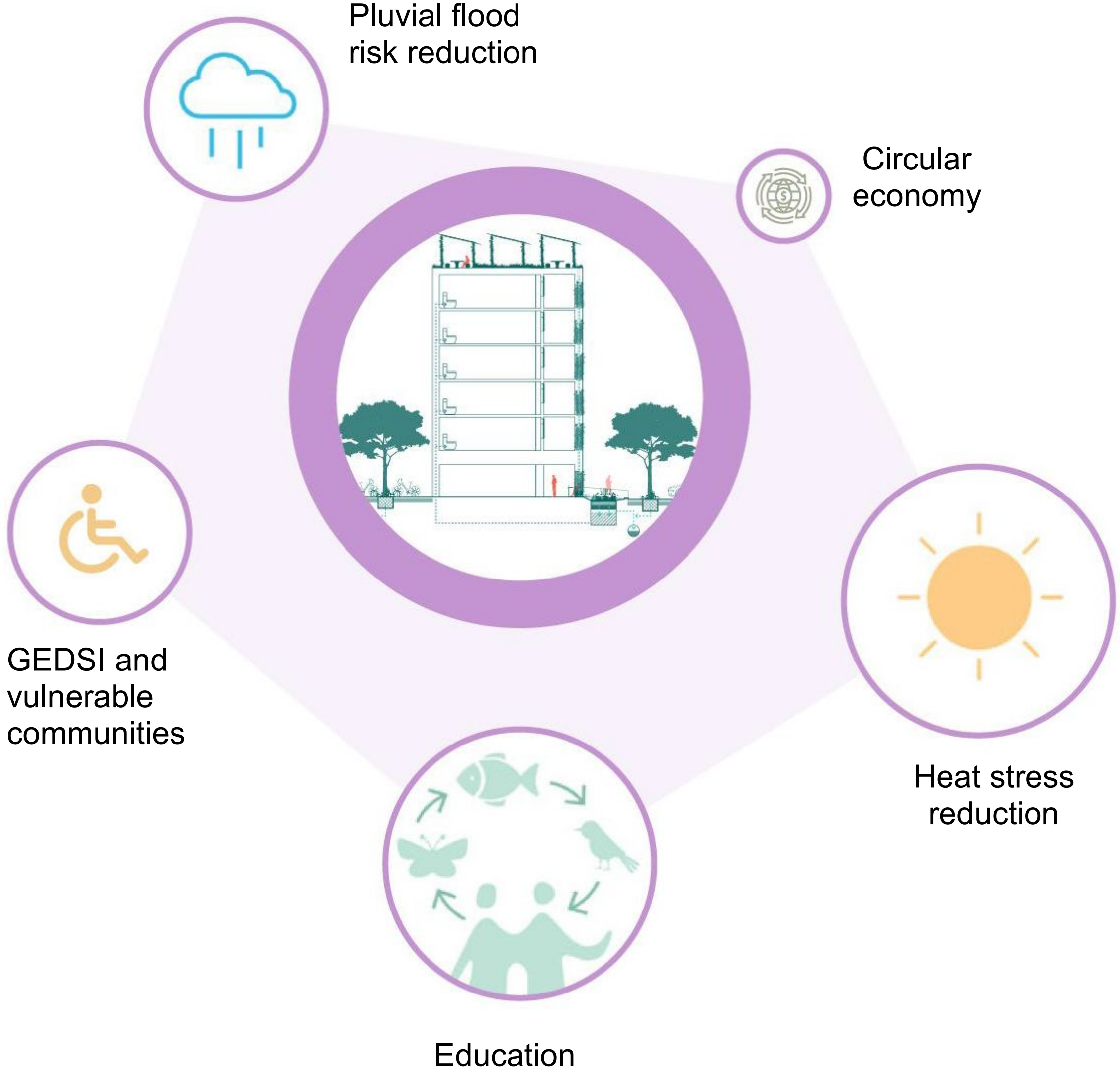


Figure SEQ Figure * ARABIC 10: Retrofit H1 building and linked yard with NbS

Source: RUCaS project team.

Benefits for HUCE



NbS Benefits

- Coastal flood risk reduction
- Pluvial flood risk reduction
- Riverine flood risk reduction
- Improved water quality
- Heat stress reduction
- Safe and healthy food production
- Tourism and recreation
- Carbon storage and sequestration
- Stimulate local economies and job creation
- Human health
- Education
- Biodiversity
- Heritage and culture
- Social interaction
- Circular economy
- GEDSI and vulnerable communities

This approach will provide several key benefits to the campus community, including urban heat mitigation with passive cooling from added green, irrigation and reduced heat reflection from the concrete yard, pluvial flood risk reduction resulting from increased infiltration, improved water quality due to the provision of nature-based filtering solutions and improved water efficiency. In addition, the project provides tangible examples for education on the benefits of NbS and opportunities for studying the impacts at a local scale. Other benefits include more diversified urban ecology and amenity for the broader community with a focus on targeted response to vulnerable population group needs, education and access for all.

The proposed approach builds on a collaboration between HUCE, the International Centre for Environmental Management and RUCaS, under the Secondary Green Cities Project supported by the Asian Development Bank. A key component of that project was a design competition for HUCE students to revision and rehabilitate an abandoned site on campus.

The competition was a unique opportunity for students to learn about sustainable and inclusive urban design. Designs had to address several challenges affecting the selected site, including ponding, heat and limited accessibility. The RUCaS team provided technical advice on inclusion in NbS at a workshop for students, and were also part of the judging panel. The RUCaS contribution looked specifically as how architecture and design can advance outcomes that promote gender equality and disability inclusion in urban renewal and design. We were guided by the following principles and commitments, which are central to our work (Figure 11).

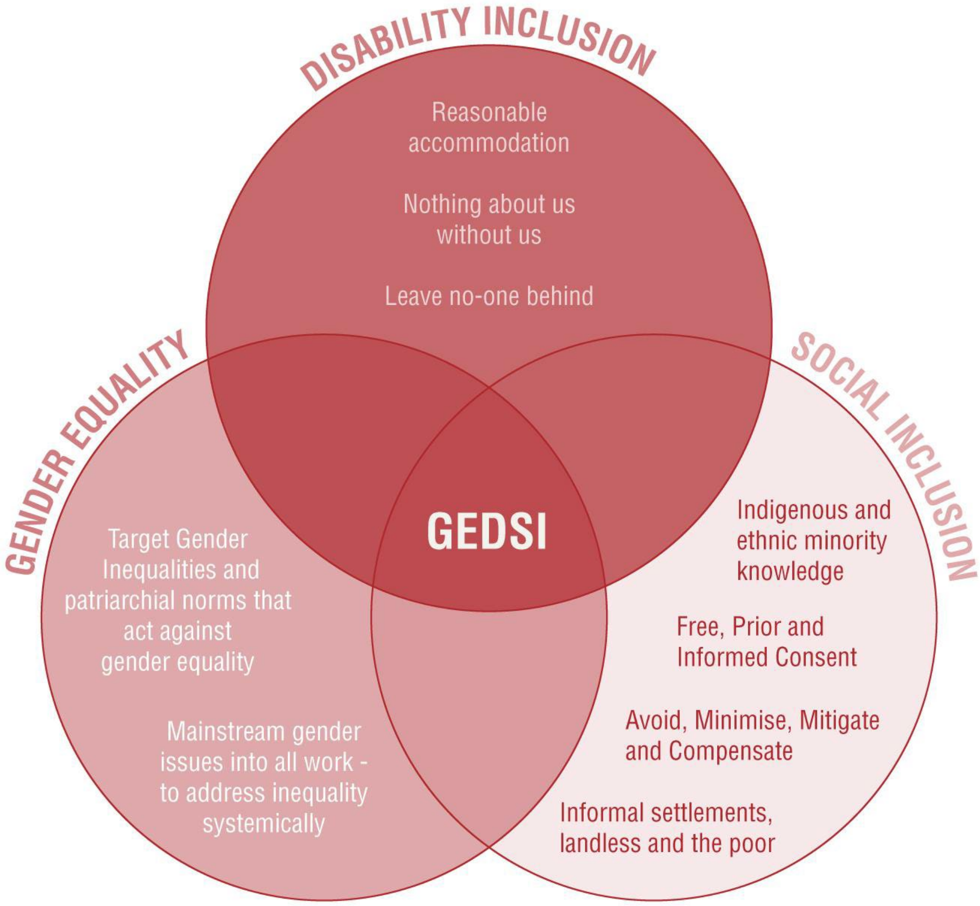


Figure 11: Linked commitments – shared approaches that centre GEDSI outcomes

Source: RUCaS project team.

3. Identify and value benefits and costs

Benefits

While the proposed approach could generate a wide variety of benefits (discussed above), the benefit–cost analysis (BCA) considered the following 6 key benefits:

- reduced temperatures on peak days, by retaining trees and adding a green wall and façade
- reduced flooding and pondage throughout the campus, by replacing concrete with porous paving
- improved amenity, by converting existing planters to bioretention planters and connecting downpipes to planters
- improved water efficiency, by harvesting and reusing rainwater for toilet flushing
- increased renewable energy, by installing a rooftop solar energy system
- improved access, by widening doors and installing ramps at building entrances, installing accessible toilets and increasing the number of toilet facilities for women.

Table 1 summarises the estimated present value of benefits for Option A relative to a 'do nothing scenario' over 20 years for the first 5 of these benefits. The final benefit (improved access) is still to be estimated.

Table 1: Total present value of benefits over 20 years

Benefit	Present value of benefits ($US)
Reduced urban heat	449,540
Improved amenity	257,351
Reduced flooding and ponding	66,911
Increased renewable energy	35,554
Improved water efficiency	627
Total	**809,985**

Source: RUCaS project team.

Because this is a preliminary study, the project team were not able to survey HUCE students and staff or businesses about our interventions. As a result, research from other places was identified and adapted to estimate the value of benefits:

- We used a previous study on introducing a multifunctional urban wetland in Ho Chi Minh City to estimate the reduced flooding benefits associated with installing porous pavements.
- We used a previous study on people's willingness to pay for urban green infrastructure in pilot sponge cities in China to estimate the improved amenity benefits of converting existing planters into bioretention planters.

- We used a previous study on the willingness of Beijing residents to pay for green roofs to estimate the reduced urban heat benefits of installing the green wall and façade.
- We used current water consumption for the H1 building, current water prices and current student numbers to estimate the water efficiency benefits of harvesting and using rainwater for toilet flushing.
- We used current data on solar energy production and electricity prices to estimate the renewable energy benefits of installing a rooftop solar system.

In all cases, estimates accounted for inflation, differences in purchasing power in different countries (where relevant), the different size of our proposed green space and the maturity of the plants.

Our assumptions about the distribution of benefits suggested HUCE students would be by far the largest beneficiaries of the proposed interventions, accounting for 81% of total benefits, following by HUCE Management. Some cooling benefits will also likely accrue to the wider residential area (although these were not estimated). Longer-term benefits in modelling good, inclusive and universal design and NbS application could accrue to the university for its teaching focus and to the wider Vietnamese citizenry for proven practice.

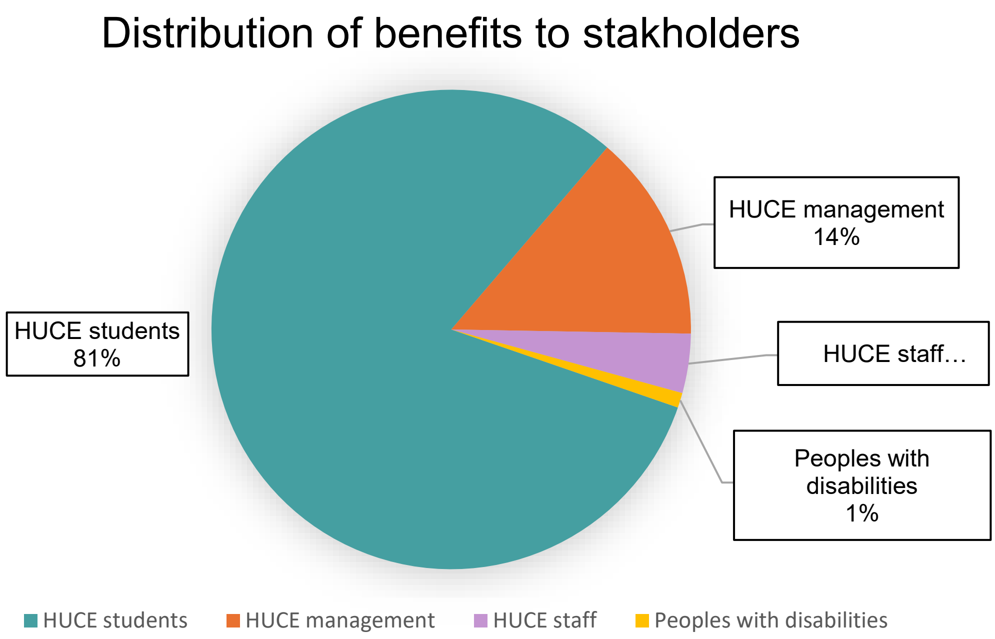


Figure 12: Total present value of benefits from Option A

Source: RUCaS project team.

The indicative nature of the benefit calculations highlight the importance of sensitivity testing (presented below) and further surveying HUCE students, staff and management before moving to implementation. A pilot project involving community co-design and surveys would be a valuable next step.

Costs

Construction and implementation; Land needs

- Bioretention planter boxes
- Porous pavement
- Green wall
- Rainwater harvesting system
- Water distribution system
- Renewable energy (solar)
- Ramps and accessible facilities

Maintenance

Maintenance costs may include:

- Infrastructure maintenance and replacement
- Green wall maintenance
- Solar panel maintenance

Other direct and indirect costs

Not applicable

The costs associated with installing the porous paving accounted for the largest share (55%), followed by the bioretention planters (18%) and the solar energy system (13%). The analysis also showed that initial construction costs accounted for around half of all costs, with ongoing maintenance and replacement costs also accounting for the other half.

All costs were borne entirely by HUCE. Currently, these estimates do not include the costs for improving accessibility (e.g. installing ramps, installing accessible toilets and increasing the number of cubicles for women).

We estimated this preliminary cost using local unit costs wherever available and international benchmarks where Vietnamese data could not be identified.

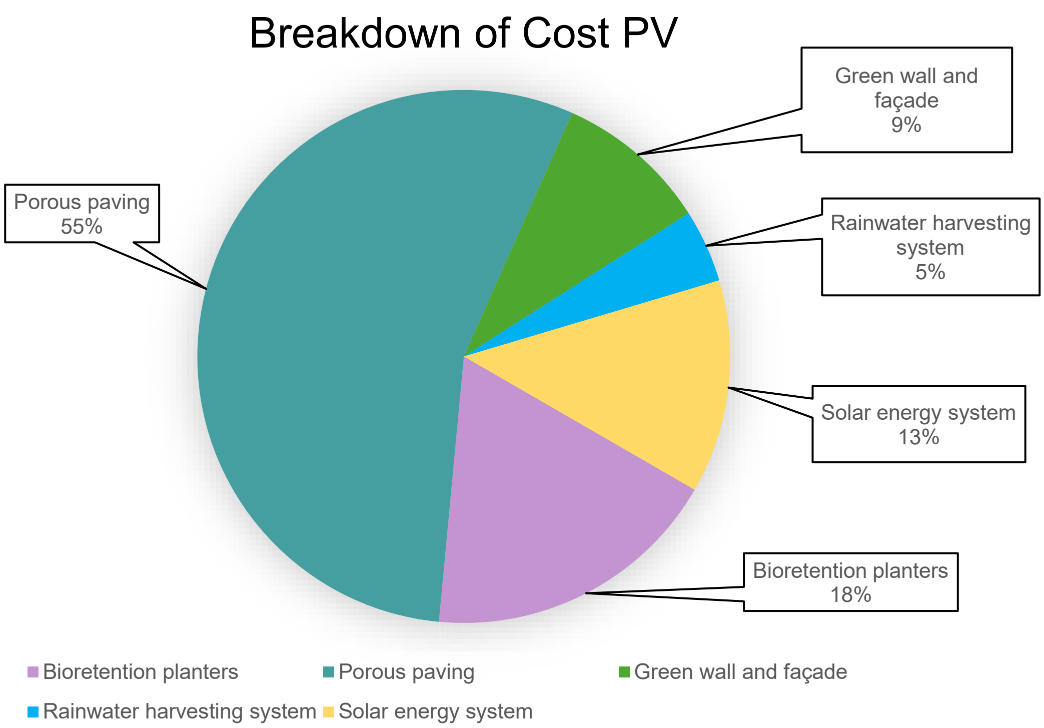


Figure 13: Total present value of costs for Option A

Source: RUCaS project team.

4. Compare and evaluate options

This case study aimed to illustrate how NbS could be applied to Building H1 at the HUCE campus in Hanoi. The costs and benefits of application to this building were estimated as a small-scale illustration that could be upscaled across the university.

Our BCA used a discount rate of 4%. We estimated all economic values over 20 years and converted them to $US.

Based on the assumptions listed above, the analysis revealed the benefits of applying NbS to H1 would outweigh the costs over a 20 year period, with every dollar of cost generating over $US3 of benefit (Table 2).

Table 2: Summary of BCA analysis findings for Option A

	Option A
Net present value (NPV)	$573,488
Benefit–cost ratio (BCR)	3.4

Source: RUCaS project team.

Figure 14 shows the distribution of net benefits over time. In the early years, upfront construction costs outweigh the benefits. However, over time the benefits outweigh the costs (e.g. as plants mature in bioretention planters and the green wall and façade mature to provide stronger cooling benefits).

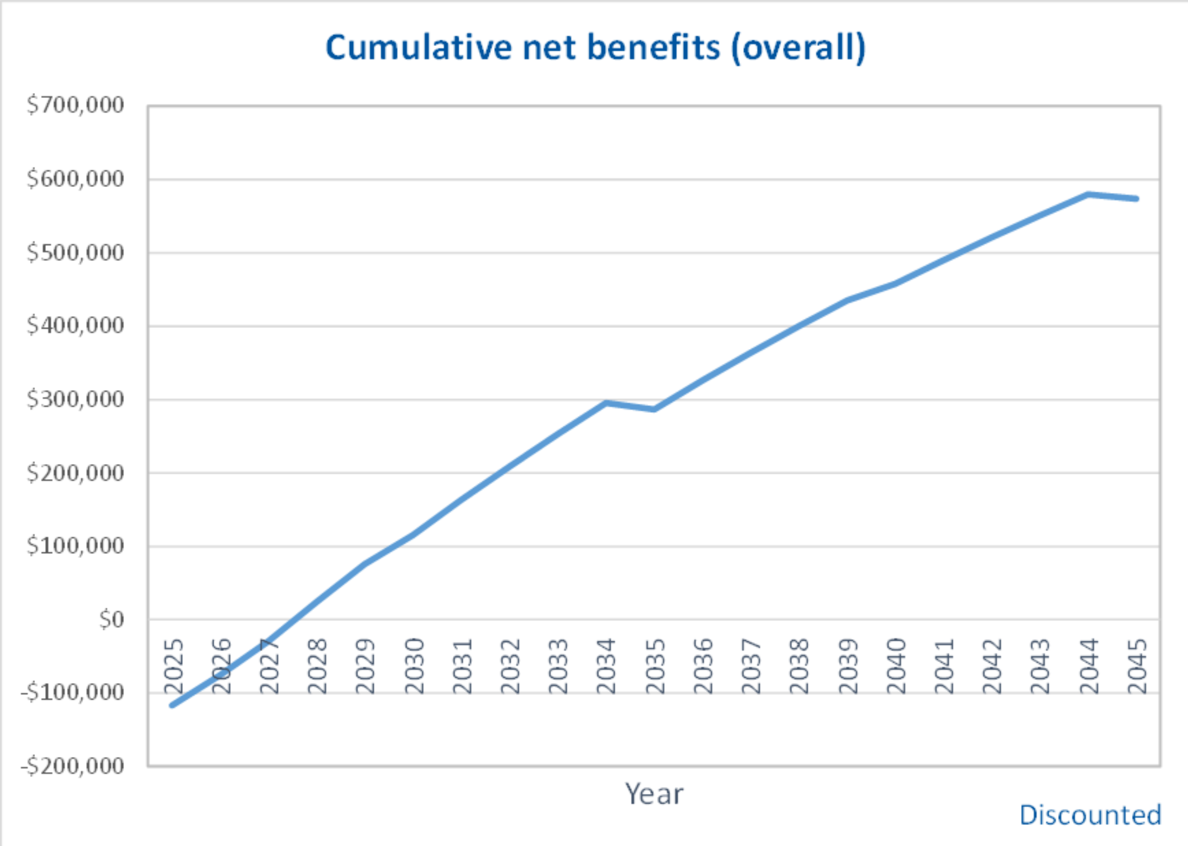


Figure 14: Cumulative net benefits over time ($US)

Source: RUCaS project team.

Given this preliminary analysis was based on several strong assumptions relating to the magnitude and timing of costs and benefits, we relaxed these assumptions through sensitivity testing to understand how robust the results are:

- We varied the discount rate, applying rates of 2% and 6% with the benefits remaining greater than the costs.
- We raised and lowered all costs and benefit estimates by 30%, and used the Monte Carlo function of the INFFEWS BCA Tool to simulate 1,000 combinations of the costs and benefits. This testing suggested the benefits always outweigh the costs, and that the most likely outcome of the analysis was a BCR between 2.0 and 3.7.

Given sensitivity testing did not provide a definitive conclusion about the merits of the project, the following factors require further investigation:

- Broader consultation is needed to refine the concept design to reflect the priorities of the community and HUCE students and staff, and confirm their views on resulting benefits.
- Cost must be further refined, ideally through a project pilot.

An important note on applying BCA

BCA is a good way of summarising the information available and identifying areas for further investigation. The next step is to use the information from various sources to make an inclusive and informed decision about the appropriate options for applying NbS to a specific site. Such assessments are best done by drawing in perspectives and expertise from a range of disciplines, stakeholder groups and affected communities. BCA is only one tool. And while it can consider costs and benefits for small stakeholder groups – such as peoples with disability – their rights and interests may be lost, forgotten or masked over by a larger or more powerful population group.

For this reason, decision makers should make special effort to engage and involve those who are vulnerable or directly impacted by the project – considering overlapping forms of vulnerability and marginalisation experienced often by women, peoples with disability and those at the margins of society such as without land or resource tenure, or people who will have to resettle as a result of the project or its operations. Inclusive approaches to early-stage feasibility, options identification and impact assessment can ensure the views of these groups are considered early in the project cycle, so the options developed are more likely to respond to their needs and rights.

5. Identify funding and financing

Traditionally, HUCE as a public university has 3 financial sources of revenue to pay for its activities:

1. State budget funding (from the Ministry of Education and Training provided annually)
2. tuition revenue (paid by students)
3. revenue from service activities, scientific research and technology transfer.

Currently, State budget funding is limited. As one of Viet Nam's largest universities, HUCE is oriented towards self-funding in coming years (i.e. through a comprehensive autonomy mechanism) and needs to identify and mobilise funding from other sources.

Securing sustainable funding and financing for our case study 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.

Enabling policy and strategy

The Resolution of the 2020 Congress of Delegates (term 2020-2025) of the Hanoi City Party Committee outlines the overarching goal: by 2030, to rapidly and sustainably develop the capital into green urban areas and a smart, modern city. By 2045, Hanoi aims to become a fully green, smart and modern city, achieving comprehensive and sustainable development. The Resolution emphasises that creating a 'green urban area' is the first step in Hanoi's journey towards becoming a 'green city' with sustainable development.

Hanoi is the capital and a special urban area that needs a system of unique and outstanding mechanisms and policies to concretise the Capital Law (amended), improve financial and budget capacity, and mobilise resources for development in the future. In particular, Hanoi needs a specific mechanism mobilising diverse capital sources, including State budget capital, domestic and foreign private capital and funding from non-government and other organisations.

The HUCE case study will propose measures to diversify forms of funding by combining funding and financing from public and private sources and involving stakeholders' participation in all stages of the project period.

Balancing centralised and decentralised solutions

A mix of centralised and decentralised financial solutions may be used to finance climate change initiatives, particularly solutions that involve citizens most vulnerable to the effects of climate change. Various financing instruments – such as public fiscal transfers, green bonds and public–private partnerships – may be available, depending on project type and sponsor.

Improving access to financing requires a robust approach to proposal development and evaluation, acknowledging all relevant costs over the project lifecycle and considering broader value adding opportunities for all stakeholders. As this case study shows, the RUCaS approach balances centralised and decentralised solutions as well as green, grey and non-structural solutions that reduce the overall costs to be financed. The case study highlights the additional values of NbS and decentralised initiatives (i.e. students' participation, community involvement in social activities etc.).

Leveraging private investment and social capital

Public finance and funding will continue to play an important role in promoting green growth.

The RUCaS approach seeks to bridge the public infrastructure gap by identifying and monetising additional revenue streams, reducing the need for public funding and increasing financability and scalability. It also seeks to unlock additional resources and impact through meaningful and effective public, private and community collaboration.

Private sector innovation and investment for NbS could be encouraged via incentives. Current national green growth policies as well as local policies create a foundation to catalyse financing streams, incentives and taxes that could be used to advance NbS implementation. For example, enterprises investing in environmental protection or green growth can enjoy tax exemptions for 4 years and a 50% reduction on corporate income tax for 9 years. Further, goods and services that contribute to greening the economy are not subject to value added tax (e.g. services from flower gardens, parks, ornamental plants and passenger transportation by electric vehicles).

Recently, Vietnamese banks have been implementing green credit packages, providing preferential conditions and incentives for investing in green sectors, including NbS projects. Green credits increased by an average annual rate of 22% between 2017 and 2022, and in 2023 it accounted for 4.4% of total credit outstanding.[31]

PPPs are proving to be critical for enabling funding for NbS projects. Viet Nam has mobilised resources from the private sector and international organisations through the green financial market. Between 2019 and 2023, Viet Nam issued US$1.157 billion in green bonds. Further, the government has committed it will mobilise public investment and private capital of US$15.5 billion for Viet Nam's green transition between 2022 and 2025.[32]

Another incentivisation scheme already operating is the green stock market. Operating since 2017, the Viet Nam Sustainable Development Index determines sustainable development standards for companies and helps potential investors identify 'green' businesses.

Taking advantage of a growing green finance system

The World Bank estimates Viet Nam may need to invest an additional US$368 billion (or 6.8% of GDP) each year until 2040 to meet its climate resilience and net-zero emissions goals. Half of this funding is expected to come from the private sector.[33] To achieve this outcome, the country must strengthen cooperation and support from the international community and deploy more innovative financial tools, including green bonds, other sustainability-linked bonds, climate-smart capital and intermediary tools.

Currently, international investment funds are ready to invest about US$15.7 billion over the next 10 years for green transformation projects.[34] The Vietnamese Government and businesses must prepare themselves to attract that significant capital source. Indeed, some businesses have successfully accessed green credit from international financial institutions.

Currently, the Asian Development Bank sponsors a project at C4 compound in HUCE under the Secondary Green Cities Project. The existing rundown one-storey building and yards will be renovated with NbS to become a NbS Training hub. HUCE can proactively develop other NbS projects that can call for additional funding from other green financing sources.

[31] Ministry of Planning and Investment (2024). *Green credit development trends in Vietnam: Current situation and solutions.* Hanoi: MPI.

[32] Government of the Socialist Republic of Vietnam (2023). 'Partners pledge $15.5 billion to support Vietnam in energy transition', *Government Electronic Newspaper*.

[33] World Bank (2022). *Viet Nam: Country Climate and Development Report*. Washington DC: World Bank.

[34] A Nhi (2023). 'Accessing green finance, businesses still don't know where to start',. *VN Economy*.

6. Upscaling and potential next steps and recommendations

Urban heat is not only a problem in Hanoi but also in other big cities. In the first 4 months of 2024, Ho Chi Minh City experienced the highest number of hot days in nearly 30 years.[35] The driving force for retrofitting existing buildings with NbS in dense urban areas therefore is strong.

This section examines the key opportunities and barriers to implementing the hybrid NbS recommended by this case study at HUCE.

Vision and policy

The National Socio-Economic Development Strategy 2021–2030 prioritises the development of critical infrastructure in transportation, energy, information technology, major cities, and climate change response. Similarly, the Resolution of the 2020 Congress of Delegates (term 2020-2025) of the Hanoi City Party Committee outlines the overarching goal: by 2030, to rapidly and sustainably develop the capital into green urban areas and a smart, modern city. By 2045, Hanoi aims to become a fully green, smart and modern city, achieving comprehensive and sustainable development.

Strategy

For strategy, it is crucial to assess the presence of enabling strategies, master plans or targets, especially for those most vulnerable to and affected by climate change and rapid urbanisation. The city's strategies and master plans align well with the HUCE case study (detailed in chapter 5). While GEDSI was not directly addressed in these strategies, other regulations provide detailed guidelines to ensure GEDSI considerations in policy formulation and project development.

Legislation and regulation

Current laws and regulations generally support the application of NbS; however, the lack of detailed guidelines, technical codes and standards complicates practical implementation. Addressing this gap requires more evidence and practical examples, detailed guidelines, technical standards and codes, increased understanding and awareness of NbS among decision makers, more practical experience among project designers and implementers, and greater community involvement in project implementation.

Community engagement

Current regulations require community and stakeholder consultation in project formulation, but this is not always properly followed in practice. So far, only teaching and management staff have been involved in the case study preparation. Moving forward, involvement of student and expert sub-groups (such as engaging with local organisations for peoples with disabilities and women's groups) is recommended through project design competitions; participation during further refinement of design options; and throughout the construction process; and with project operation and maintenance. Ensuring a gender equality approach and ensuring GEDSI practices are incorporated and resourced, such as constructing accessible paths and organising social events, will further enhance engagement.

Options

While current regulations support the identification and valuation of projects, they do not include guidelines for project maintenance costs, posing a challenge for HUCE management in allocating funds. Additionally, while current legal frameworks support BCA for conventional projects, they often overlook intangible costs and benefits, making it difficult for HUCE leaders to approve NbS projects.

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[35] V Duc (2024). 'Saigonese suffer longest heat wave in 30 years', *VN Express*.

Current regulations do mandate stakeholder consultation, including GEDSI considerations, and some construction guidelines include GEDSI elements.

Project delivery and operations

The HUCE H1 NbS retrofitting must consider lifecycle costs and the capacity to build and operate hybrid options. Our analysis accounted for 40-year lifecycle costs. However, HUCE currently lacks the capacity to build and upscale NbS in other university areas, necessitating training on NbS design, project preparation and BCA. Similarly, capacity building is needed to operate and maintain hybrid options.

We identified the following short- and long-term recommendations to facilitate broader application of NbS in Viet Nam.

Short-term recommendations:

- Raise awareness about NbS concepts among all stakeholders.
- Ensure stakeholder and community involvement from the beginning of the project process.
- Provide coherent and transparent information about NbS project preparation and implementation.
- Strengthen training and capacity building.

Long-term recommendations:

- Revise and amend existing legal documents to include guidelines on NbS standards, designs and costing norms.
- Develop comprehensive guidelines for NbS project preparation, implementation and maintenance.
- Introduce NbS education, training and professional development into the universities' curriculum to new students and existing professionals in universities to build human resource capacity and skills for the planning, designing and implementation of NbS projects.

Appendix 1: Case Study methodology

Each case study follows the 5-step process for identifying, valuing and choosing an appropriate mix of interventions for a particular context.[36]

[36] The Integrated Urban Climate Management (IUCM) framework extends the Integrated Urban Flood Management framework developed with the World Bank and applied in China: 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.

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