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## Nature-based Solutions in Viet Nam: Challenges and Opportunities

### Solutions fondées sur la nature au Viet Nam: Défis et Opportunités

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#### RÉSUMÉ

Le changement climatique affecte gravement toutes les régions du monde. Au cours de la dernière décennie, les inondations ont causé les dommages économiques les plus importants d'Europe et la gestion des eaux pluviales est devenue un défi urbain majeur. En tant que pays extrêmement exposé au changement climatique, le Viet Nam est confronté à de graves inondations urbaines provoquées par des pluies intenses. Pour atténuer la pression sur le système de drainage urbain, une transition vers des solutions fondées sur la nature (NBS), ou des infrastructures bleu-vert, ou une gestion décentralisée des eaux pluviales dans les zones urbaines a été largement appliquée. La NBS pour la gestion des eaux pluviales urbaines vise à contrôler les volumes et le calendrier des ruissellements de surface et ainsi à réduire les risques d'inondation lors d'événements de précipitations extrêmes. Cependant, les mesures d'adaptation actuelles au Viet Nam se concentrent principalement sur des mesures techniques, qui subissent la pression de l'évolution des caractéristiques des précipitations et la compréhension du NBS est encore limitée. Bien qu'il existe des obstacles importants, les opportunités de mise en œuvre des NBS sont évidentes. Cet article examine les défis et les opportunités actuels entourant l'adoption des NBS au Viet Nam et explore les approches NBS des Européens qui peuvent être utilisées au Viet Nam. Les résultats de cette étude peuvent être appliqués pour promouvoir les NBS dans d'autres municipalités des pays en développement.

#### ABSTRACT

Climate change severely impacts all regions around the world. In the last decade, flooding has caused the highest economic damage in Europe, and stormwater management has become a severe urban challenge. As a country extremely exposed to climate change, Viet Nam is facing severe urban flooding due to intensive rainfall events. To mitigate the pressure on the urban drainage system, a shift towards nature-based solutions (NBS), or blue-green infrastructure, or decentralized stormwater management in urban areas has been widely applied. NBS for urban stormwater management aims to control surface runoff volumes and timing and thus lower the flooding risks during extreme precipitation events. However, current adaptation measures in Viet Nam mostly focus on engineered measures, which are being pressured by the changing precipitation characteristics and the understanding of NBS is still limited. While significant barriers exist, the opportunities for NBS implementation are obvious. This paper discusses the current challenges and opportunities surrounding the uptake of NBS in Viet Nam and explore which Europeans' NBS approaches can be used in Viet Nam. The findings from this study can be applied to promote NBS in other municipalities in developing countries.

#### KEYWORDS

Nature-based solutions, Urban stormwater management, Climate change adaptation, Urban flooding, Barriers.

## 1 INTRODUCTION

Viet Nam is a country located in Southeast Asia and bounded by the Pacific Ocean, with a total land area of 331,235.97 km<sup>2</sup> and a coastline of 3,260 km. Due to the country's long coastline, Viet Nam is facing the risks of climate change and sea level rise as it ranked 13<sup>th</sup> on the 2019 Global Climate Risk Index (David Eckstein, 2021). Climate extremes in Viet Nam were recorded with higher intensities and frequencies. Between 1958 and 2018, the annual average precipitation of the whole country increased by 2.1%, in which the most increase observed in South Central Coast (United Nations Climate Change, 2022). For a developing country like Viet Nam, most urban areas have observed high population density and continuing rapid urbanization with sealed surfaces and densely compacted soil replacing the naturally permeable landscape. As a result, such urban areas have frequently witnessed severe urban flooding due to overloading of the drainage systems through an increasing number of extreme events caused by changing climatic conditions (Oral et al., 2020). To date, there are abundance of engineered approaches to addressing climate change-related risks, natural disasters and climate change, such as sea walls, levees, pipes or irrigation infrastructure (Jones et al., 2012). However, these conventional infrastructures often route runoff to the sewerage system during extreme precipitation events or directly to streams and rivers, intensifying pollutant inputs and hydrological disturbance (groundwater recharge, evapotranspiration) and leading to a degradation of the ecosystem's structure and function (Roy et al., 2008). A new respond towards nature-based solutions (NBS), or blue-green infrastructure, or decentralized stormwater management in urban areas has been widely applied. Much more NBS practice evidence has been conducted with more focus in Europe and other parts of the Global North. However, developing nations and communities in the Global South, which are more vulnerable to climate impacts, have received less attention in the evidence (Chausson et al., 2020; Kabisch et al., 2016; Vojinovic et al., 2021). Some Vietnamese legal documents have also mentioned climate change adaptation and NBS but there is an overall lack of comprehensive understanding of NBS' uptake and development process, furthermore, the proposed solutions for NBS's barriers are also rare.

## 2 METHODS

### 2.1 Case study area

Viet Nam has both a tropical climate zone and a temperate climate zone and all of the country have affected by the annual monsoon. Rainy seasons correspond to monsoon circulation, which brings heavy rainfall in the north and south from May to October, and in the central regions from September to January (The World Bank Group and the Asian Development Bank, 2021). Located in the central Viet Nam, Da Nang city has received heavy precipitation in the winter, particularly in September, October, November and December, as the total monthly rainfall in the period of 2011 – 2021 are shown in the Table 1.

Table 1. Monthly precipitation in mm in Da Nang from 2011 – 2021 (Data collected from General Statistics Office of Viet Nam, 2022)

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
<b>2011</b>	160.6	0	31.2	8	35	100.5	12.8	139.1	812.1	791.3	1218	339.2
<b>2012</b>	56.8	37.4	0	21.3	10.9	46.1	32	180.5	581.7	367.5	302.4	59.5
<b>2013</b>	17.8	44.5	44.6	14.2	43.3	25.2	131.5	80.7	750.8	369.4	760.3	34.4
<b>2014</b>	86.6	0	3.9	63.2	5.5	82.4	183.6	180.8	111.5	819.4	288.1	399.1
<b>2015</b>	24.2	12	179.3	89.7	34.6	24.8	36.8	190.9	416	356.1	328.2	179.8
<b>2016</b>	74.2	5.4	13.8	0	59	47	54.3	145	783.3	411.2	336.8	758.7
<b>2017</b>	134.9	60.3	18.7	32.8	76.6	33.6	248.2	178.7	198	363.5	776.6	163.5
<b>2018</b>	22.8	11.9	30.3	146.1	5.2	150.7	184.4	55.4	139.6	253.4	260.6	1278.7
<b>2019</b>	270.3	1.4	34.4	0	53	11.2	65.1	174	307.7	637.8	464.9	130.6
<b>2020</b>	46.2	3.7	30.3	114	64.2	0.4	56	67.4	309.3	1754.9	486.2	143.6
<b>2021</b>	34.7	32.1	14.6	24.1	2.1	38.5	12.5	93.5	800.4	782.8	271	485.8

Da Nang is the biggest city in the South Central Coast of Viet Nam, with the total area of 1,285 km<sup>2</sup>, of which the urban area is 241.51 km<sup>2</sup>, and populated by approximately 1.1 million citizens (Kamei, 2022). The city's topography is diverse, comprising of both coastal plains and mountainous areas. High and steep mountainous areas with a high range between 700m and 1500m concentrate in the west and northwest, whereas low-lying

coastal plains lay on the south and east (Figure 1). Similar to other urban regions in Viet Nam, the city has a combination of sewerage and drainage systems, which are mainly located in the stone-paved roads. Stormwater and wastewater are collected together in the same sewage network. Only parts of newly planned regions have separated collection systems to wastewater treatment plants. Such conventional drainage networks are currently facing aging problems and not always sufficient to collect and discharge the runoff caused by intensive climate change-induced rainfall events, often leading to severe urban floods (Viet Nam Ministry of Construction, 2017). In recent years, urban flooding is more difficult to predict and caused historic floods, for instance, several extreme floods were observed in December 2018 and October 2022 in Da Nang due to heavy rainfalls. On 9 December 2018, a record-breaking rainfall of 972mm was observed in 24 hours; and the downpour of 795 mm in 11 hours, of which 500mm in the first six hours on 13 October 2022, caused the entire city inundated by up to 1.5m.



Figure 1. Topography of Da Nang city (Source: Da Nang Construction Planning Institute, 2020)

A ‘near-nature’ strategy is required to improve the situation and to retrofit the performance of the conventional drainage system in views of uncertainties associated with climate change. Natural Based Solutions (NBS), or Low Impact Development (LID), or decentralized stormwater management systems aim to lessen the negative impacts of runoff quantity and quality caused by urbanization to allow regional runoff processes mimicking natural stormwater control mechanisms (Prince Geogre’s County, 1999). Its meaning has been extended in many countries that have similar terms regarding stormwater management, for instance, Water Sensitive Urban Design (WSUD) in Australia, Sponge City in China, or Sustainable Urban Drainage Systems (SUDS) in the UK (Fletcher et al., 2014).

This study will implement several NBS or LID practices, which are widely used in Europe, to evaluate their performance in terms of flood mitigation when introduced to Da Nang city by modelling.

## 2.2 Methodology

The U.S. Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) will be used to model different LID practices for the runoff quantity simulations under current and future climate. Climate and precipitation data will be obtained from Hydro-Meteorological Center in Mid Central Viet Nam. Stormwater pipe network data will be acquired from Da Nang Drainage and Wastewater Treatment Company. Land use information will be obtained from Adjusted Planning Report in 2020 of Da Nang Construction Planning Institute.

To develop a low impact development site plan, it is required to determine the runoff curve number (CN), similar to conventional site plan and stormwater management approaches (Prince Geogre’s County, 1999). In order to determine the CN, a detailed evaluation of each land cover within the study site is calculated (Rossman, 2015). After that, LID parameters will be investigated, optimized and selected for the sensitivity analysis. This step aims to determine which LID parameters have most significant impact on drainage network performance. Then, a process of calibration and validation is conducted with observed precipitation data and designed precipitation processes to ensure the simulation results are realistic.

Performance of LID systems, centralized system and a combination of decentralized and centralized systems will also be investigated by various scenarios analysis to access the flood mitigation effectiveness.

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### 3 EXPECTED RESULTS

We investigate single and multiple combinations of LID tools, and between LID tools and conventional measures, to determine the most effective practices in urban stormwater management under the context of climate change.

Site opportunities and constraints when adopting LIDs in Viet Nam will be evaluated. Collecting this information together with other climate zones in Europe and Asia help to find barriers and enablers in NBS implementation in developed and developing countries. This may help to find out appropriate adaptation strategies among these countries.

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