Management of drainage network on Southern bank of Huong River in Hue City in the context of climate change

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Abstract

This paper aims at proposing solutions to enhance efficiency ofthe drainage network onthe Southern bank of Huong River in Hue City in the context of climate change. Southern bank of Huong River area has an elevation of 2 to 4 meters, but in severallocations, the elevation is very low, only 0.5m. After heavy rains, some locations are flooded for several days. Under the impacts of climate change,unseasonal rains with high intensity have caused inundation for wards of Vy Da, Xuan Phu, Vinh Ninh, Phu Nhuan, An Cuu, Phuong Duc, etc.,affecting the people's lives and local infrastructures. Currently, the drainage network on the Southern bank of Huong River area has been invested with the new construction of sewers, interceptors, overflow chambers,etc., however, the flooding situation has not been solved. From the analysis results, the paper offers some solutions to improve the drainage network capacity as well as to enhance the City's resilience in the context of climate change, including consideration of additional design parameters, technological management and use of sustainableurban drainage solutions (SUDSs) for the City.

Key words: *drainage network, climate change, Southern bank of Huong River.*

HEPCO: Hue Urban Environment and Public Works Joint Stock Company

ODA:Official Development Assistance

RCP: Representative Concentration Pathways

SUDS: sustainable urban drainage solution

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1. Introduction

Vietnam is one of the countries most heavily affected by the climate change. Increasingly complex and unpredictable weather patterns have caused serious infrastructure damages and human mortality [1]. Climate change has been a major challenge for humanity, especially issues such as flooding, drainage of low ground areas, protection of river and lake ecosystems, clean water supply, exploitation of water resources, water for farming, transportation, and in the management of dams and reservoirs [2]

The urban drainage system is an important city infrastructure to collectand transport stormwater and wastewater away from urban areas. Although it has evolved over the years, designing an efficient drainage system remains a major challenge. In particular, the impacts of climate change and urbanization are widely recognized, which can lead to a significant increase in the frequency and intensity of urban flooding in many regions of the world[3].

Therefore, in recent years, there have been many studies in the world as well as in Vietnam on strengthening the capacity of the drainage network to adapt to climate change. The study on Optimization of the drainage system under climate change scenarios is one such example. The authors argue that the increasing frequency of extreme rainstorms due to climate change calls for cost-effective methods to optimize drainage networks and measures to mitigate flooding risks[4].

Besides, urban drainage systems in general fail to perform their function mainly due to unstable climate and rapid urbanization process. As these systems are becoming less efficient, problems such as overflowing sewers and increasing urban flooding leading to an increase in pollutant loads on receiving waters are becoming extremely common. Yazdanfar and Sharma (2015) pointed out the need for a comprehensive survey to understand the impact of these factors on the performance of urban drainage systems, and how these factors vary in space and time and their complexity when combined. In addition, the study also shows that adaptation measures need to be carefully selected to ensure the sustainability of the drainage system to meet the combined challenges of climate change and urbanization. The study also examined the challenges associated with urban drainage systems and explored the limitations and potential of different adaptation solutions. The research was conducted with the aim of providing drainage engineers, water planners and decision makers with the most advanced information and technology on adaptation options to increase system efficiency in conditions of climate change and urbanization[5].

In fact, many infrastructures have been built in low-lying areas prone to flooding and measures and solutions to reduce flooding mainly focus on construction solutions. Public participation in the development of future flood management principles has benefited both stakeholders and engineers. Suggested methods to improve the problem include increasing the drainage capacity, using the pond system as reservoirs, constructing pumping stations and culverts. To assess the impact on the drainage system under the conditions of projected increased rainfall due to climate change, for each approach, simulations were performed to show the extent and depth of inundation. The results show the importance of assessing the impacts of climate change in implementation of appropriate flood management methods [6].

Hue city is the political, economic, cultural and social center of Thua Thien Hue province, home to a complex of human cultural heritage recognized by UNESCO. Hue is a grade 1 city, an important urban center in the national urban system and one of the key cities in the central region. Hue was formed in the center of the narrow delta of the lower Huong River and is divided into two main areas, consisting of North of Huong River and South of Huong River.

In particular, the area south of the Huong River has a very large difference in elevations, ranging from +2,0m ÷ +4m, and Dong Ba, Ba Trieu, Nguyen Cong Tru areas are the lowest, with elevation of only 0.5m. Therefore, this area is often flooded and threatened by floods, and regularly flooded when there is moderate and heavy rain at the upstream of Huong River (on the Truong Son Mountain Range) [7]. Over the past decades, the most obvious manifestations of climate change in the study area include floods, heat, drought, landslides, and saltwater intrusion, threatening the lives and livelihoods of local people, the ecosystem and local infrastructures. In the current climate change context, dangerous weather phenomena such as storms, thunderstorms, whirlwinds, natural disasters related to temperature and rain are forecasted to increase in number and influence on Hue city in particular and Thua Thien Hue province in general. Besides, like other provinces with hydroelectric projects, the management of drainage in Hue city is more difficult because the operation of the reservoirs leads to floods. Climate change would increase inundation in Hue city by 31.8% by 2050. The risk of flooding also comes from threats of storm surge occurring at the same time with heavy rains, and challenges from the management of upstream reservoirs. Rain is the most variable climate factor in Hue city [8].This makes flooding on the south bank of Huong River increasingly difficult to control and shows the importance of improving the efficiency of the management of the drainage system with aims to protect property and people's lives, enhance resilience to climate change and ensure sustainable development for Hue city.

2. Methodology

2.1. Scope of study

The study scope is the urban drainage network on the southern bank of Huong River (according to the division of administrative boundaries of Hue city by Decree No. 44/2007/ND-CP, dated March 27, 2007) and Resolution No. 14/NQ-CP, dated March 25, 2010 of the Government) with 10 wards of Vinh Ninh, Phu Nhuan, Phu Hoi, Xuan Phu, Ward Duc, Phuoc Vinh, Truong An, An Cuu, Vi Da and part of An Dong ward with a total area of 1010 ha as shown in the Figure 1.

2.2. Methods of study

Collection of secondary data: with information and data about the study area, the current situation of the drainage network, operation capacity, the current inundation, scenarios, etc., from various parties including PMU of Hue City Water Environment Improvement, Project Consultants, HEPCO, etc. and from previous research.

Site survey: Survey and collection of information on the current situation of the drainage network in the Southern bank of Huong River.

Data processing and analyzing: The information is collected, synthesized and analyzed to assess the current situation of the drainage network, climate change situation in Thua Thien Hue province, impacts of climate change on mentioned drainage capacity.

Consultation of experts: The experts are consulted in assessing the current situation of the drainage network, proposing measures for management of the drainage network in the context of climate change.

Map and diagram: The paper are used the surface water drainage planning of Hue City and other drainage networks.

2.3. Data sources

Fig. 1. Southern bank of Huong River [12]

The main documents used by the authors in the study process include 1) various project reports for Improvement of Water Environment in Hue City (Japanese ODA); 2) Project Report for Green Cities in Thua Thien Hue Province (ODA from ADB); 3) Surface water drainage planning of Hue City, Thua Thien Hue Province; 4) Summary report on climate assessment for Thua Thien Hue Province (DoNRE of Thua Thien Hue province, 2021); and 5) Final Report on Development and Update of Action Plans in Response to Climate Change in Thua Thien Hue Province (DoNRE of Thua Thien Hue Province, 2021).

3. Results and discussion

3.1. Climate change in Hue City

Hue city is an urban area in Thua Thien Hue Province - a central coastal province of Vietnam, located in an area highly vulnerable to the impacts of sea level rise, heavy rain, storms and tropical depressions, etc. Climate change affects many regions, localities, sectors of the province, especially water resources, agriculture, industry, energy, construction, urban areas, tourism and people's lives. In recent years, the manifestations of climate change in the study area have become increasingly clear such as increase both in frequency and intensity of average temperature, rainfall, extreme events, and with unpredictable, irregular changes [9].

In the period from 2010 to 2019, due to Elnino influence, the rain situation changed against the rules, such as the heavy rain on November 15-17, 2013 with great intensity of 68.5mm/h at Kim station Long and 78mm/h at Hue station. The rainfall in 3 hours, from 16:00 to 19:00 on November 15, 2013 was 185mm at Hue station, 134 mm at Kim Long station and 172mm at Phu Oc station. This caused the most serious flood due to heavy rainfall intensity since the flood in 1999. In 2015, right from end of March, there was a heavy rain on a large scale, with rainfall from 380-620mm. This is an unseasonal, unusual and unprecedented heavy rain in the period of the winter-spring crop, and the heavy rain upstream led to floods in the rivers and widespread flooding. In 2016, due to the influence of climate change and the transition from El Nino to La Nina, from early September to mid-December,

throughout the province, natural disasters, storms and floods occurred consecutively. In 2017, heavy to extremely heavy rains concentrated in October and November, especially heavy rains in November, causing huge to especially huge floods throughout the province. The flood was especially massive from November 3 to November 9, 2017 with the total rainfall from 7 p.m. on November 3 to 7:00 a.m. on November 9 of 600 to 1200mm, and even higher at Bach Ma (2,751 mm), a flood of III level alarm appeared on the Huong and Bo rivers. The peak flood water level was +4.03m at Kim Long on Huong River at 19:00 on November 5, which was 0.53mover of III level alarm; +5.05m at Phu Oc station on Bo River at 5:00 p.m on November 5, which was 0.55m over of III level alarm, approximately the historical flood peak of 1999 (+5.18m). The huge flood lasted from November 19 to November 24, 2017 was with average rainfall from 360 to 800mm, and even 1,028mm at Bach Ma resulting into massive flood on the river banks. The highest peak flood water level on Huong River was + 2.71 m at Kim Long, which was 0.71 m over of III level alarm; on Bo river, it was +4.17 m at Phu Oc, which was 0.33m under III level alarm. In 2018, due to the increasing influence of cold air combined with high-altitude easterly wind disturbances, from the morning of December 7 to December 17, 2018 in Thua Thien Hue, there was moderate rain, heavy rain, and torrential rain with average rainfall from 200mm to 400mm, in Hue it was 392mm.[9]

The most recent event was the rain on October 14-15, 2022 with an average intensity in 24 hours of 450-500mm. At 3 a.m. on October 15, the water level of Huong River was +3.73m at Kim Long, which was 0.23m over III level alarm; Boriver water level at Phu Oc station was +3.97m, which was0.53m under alarm III is. Heavy rains resulted inmassive flooding, resulting into more than 11,200 houses to be flooded from 0.3-0.8m.

Under the impact of climate change, temperature and rainfall in Hue have changed.

Temperature: Figure 2 shows the annual variation of the average temperature at Hue monitoring station in the period of 1976-2019 and the assessment period of 2010-2019. The data show that the annual variation of the mean temperature over the period is similar. However, there is a clear difference in the number of months.

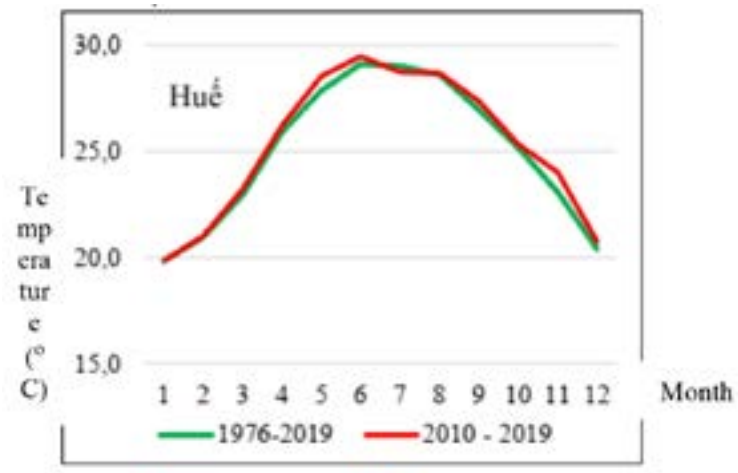

Fig.2. Annual variation of temperature (°C) for the period 1976-2019 and 2010-2019[9]

Rainfall: The annual rainfall pattern at Hue station in the assessment period compared to the period of 1976-2019 not only increased in volume but also diverged in heavy rainfall towards the end of the year. According to Figure 3, the long period with the largest amount of rainfall was in October, while the period of assessing the peak rainfall was skewed to November and the annual December rainfall has an increase of approximately 100 mm. Therefore, the climate change has made the rainy season in the region end later and the rainfall also increases sharply in the last two months of the year. In addition, annual rainfall in Hue in between the two periods indicates that the heavy rainfall was both at the end of the year and the heaviest rainfall was in November as shown in Figure 3.

As such, in comparison of the period of 2010-2019 and the standard climate period of 1981-2010, the rainfall in the study area changes at an average of 2%, i.e., 2.2% in the dry season, and1.9% in the rainy season.

In addition, due to the impact of climate change, the number and frequency of disasters such as large-scale heat, drought, storm and tropical depression, floods, severe cold, fog and hail, etc. show tendency of increase.

3.2. Climate change scenarios of Thua Thien Hue Province

The climate change scenarios have been developed for Thua Thien Hue Province, with the emphasis on RCP4.5 and RCP 8.5 scenarios on basis of Climate Change Scenario of MONRE in 2016 [10].

Average temperature: According to all RCP scenarios, in all three periods of the beginning, middle and end of the 21st century, the annual and seasonal average temperatures in Hue tend to increase compared to the baseline period. By the end of the 21st century, the increase in temperature is greater. In which, the RCP8.5 scenario usually gives the largest increase and the difference is quite clear with other scenarios. According to the scenario RCP4.5, the annual temperature and seasons will increase by 0.7 0C at the beginning of the 21st century, by 1.50C by the middle of the century, and by 1.9oC by the end of the century. Under the RCP8.5 scenario, the annual temperature could increase to 3.50C. In general, the temperature increase is quite uniform in each scenario and period.

Annual rainfall: There is tendency of sharp increase compared to the base period. According to the RCP4.5 and RCP8.5 scenarios, annual rainfall will increase at 20 ÷ 22% at the beginning of the century, 32% in the middle of the century, and 26 ÷ 31% at the end of the century.

3.3. Current situationof drainage network and management

3.3.1. Existing drainage network on Southern bank of Huong River

Key drainage works: rivers including Huong, Nhu Y, An Cuu, Nhat Dong, Phat Lat and drainage channels such as Moc Han, Ba Niem, Nhat Tri, etc and the lakes in the area.

Sewerage network: Most of the semi-separate sewer systems have been renovated and newly constructed in the Hue City Water Environment Improvement Project - Phase 1 (Japanese ODA, 2008-2020) and a small part is a separate drainage system (separate drainage of rainwater and wastewater) recently built in An Van Duong New Urban Area.

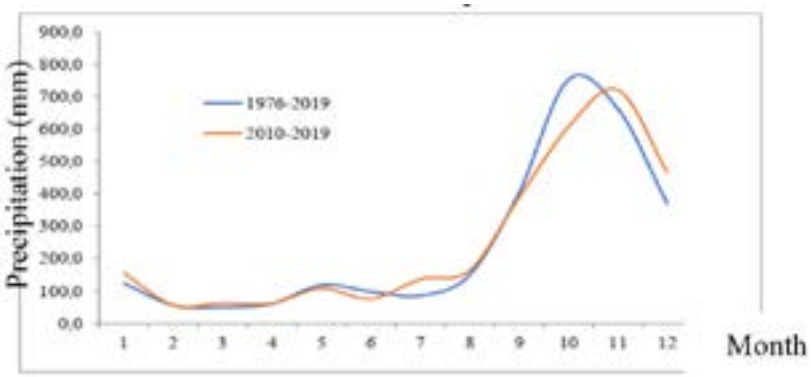

Fig. 3. Annual precipitation (mm) in the period 1976-2019 and 2010-2019 at Hue station[9]

Within the above mentioned project, the drainage network in the densely populated inner city wards on the Southern bank of Huong River have been enhanced and built to collect both rain water and wastewater. At the outlets into the key drainage works (rivers, lakes, canals), the overflow chambers are provided to collect the wastewater and initial stormwater into the interceptors which then transfer the flow to the wastewater treatment plant for treatment to required standards before discharge into the environment. The main measures, which have been constructed within the project scope, consist of the followings.

(1) Dredging and embankment of key drainage works including An Cuu river (0.746km); Nhu Y Bac river (1,456km); Canal No. 7 (0.616km); Moc Han canal (1,396km);

(2) Rehabilitation and construction of the combined sewers, including renovation and replacement of old culverts and new construction of primary and secondary sewers (38,663m); tertiary network for the whole project area (74,700m); and 107 outlets;

(3) Renovation and construction of the wastewater sewers system, including the construction of a new interceptors (32,406m); 94 overflow chambers; 07 pumping stations;

(4) Construction of 1 new waste water treatment plant using activated sludge treatment process, with the capacity of 30,000 m^3/day in An Dong ward with a total area of 9.6 ha.

The project scope is illustrated in Figure 5 below [12]:

In addition, in the period 2018-2024, Component 1 - Flood prevention and environmental sanitation under the Green Cities Project in Thua Thien Hue Province (ADB fund) has been implemented improve the drainage network for the inner city area on the Southern bank of Huong River in Hue city, including enhancement and embankment of two banks of An Cuu river (0.5km); Nhu Y river (0.35km); and drainage, trees, sidewalks, lighting system for the central ecological routes of An Van Duong urban area [11].

Furthermore, in the period of 2021-2024, Hue City Water Environment Improvement Project, Phase I (residual capital) has been extended for enhacement of the drainage system on the Southern bank of Huong River [12]. The proposed measures include the below items.

(1) Separate sewer lines to collect wastewater for Zone A, An Van Duong urban area and for the remaining areas of An Van Duong urban area with total length of 23,502m;

(2) Construction of additional combined sewer lines with a total length of 7,300m;

(3) Embankment of Nhu Y river (13,846m); An Cuu river (365m); Long Tho - Thuy Bieu canal (1,900m);

(4) Additional storm water and wastewater drainage for Bau Va area, total length of 647m;

(5) Drainage for Pham Van Dong roadside, length of drainage system of 3,100 m;

(6) Combined sewers downstream of 245 Phan Boi Chau lane, total length of 1,010m.

Therefore, in recent years, Hue city's drainage network has continuously been invested for new construction and improvement in order to have a comprehensive drainage network.

3.3.2. Drainage network management

According to Decision No: 51/2017/QD-UBND of Thua Thien Hue Provincial People's Committee issued on July 6, 2017 on regulations on management of drainage and wastewater treatment activities in Thua Thien province, the owner of the drainage system in Hue city is the People's Committee of Hue city.

Before the construction of the Hue City Water Environment

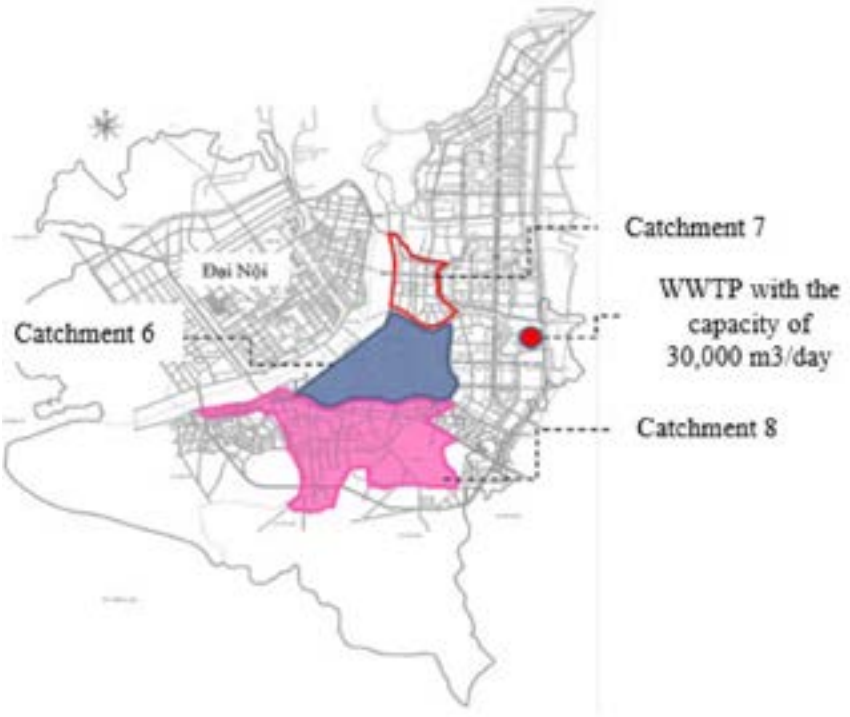

Fig. 4. Scope of Hue City Water Environment Improvement Project[12]

Fig. 5. Outlets of combined sewers into An Cuu River at Ton Quang Phiet Str.

Fig. 6. Flooding in some areas on southern bank of Huong River[13]

Improvement Project, the Hue Urban Environment and Public Works Joint Stock Company (HEPCO) was assigned the task of maintaining the drainage system in Hue city via the contract signed with the People's Committee of Hue City. Since the project construction in 2015, the project construction site has been handed over to the Project.

The project has been basically completed in 2020, the project owner is conducting the bidding process for selection of an operator for the drainage and wastewater treatment system in the city according to the above Decision.

3.3.3. Dewatering capacity of drainage network under climate change context

Although the environmental improvement projects have contributed to the increased drainage capacity of the drainage network on the Southern bank of Huong River, currently, the drainage network has only been built in the inner city, showing certain limits in dewatering, especially in the rainy season, leading to flooding in many wards and communes on the related areas, especially in An Van Duong new urban area.

Besides, in An Van Duong urban area, the key drainage works such as the system of lakes and ditches/drainage channels have not yet been constructed according to the planning, resulting into inundation during and after rain.

Furthermore, there are still old and degraded sewers in the areas, or outlets which are lower than the river level that leads to the backflow of water into the sewers as shown in Figure 6 below, making the flooding more serious.

In addition, due to the lack of tools to provide local people with necessary information when floods occur, human and property damages and losses are still very high.

In the rain event on October 14-15, 2022, many streets were flooded with the average depth of 0.3-0.5m, and even over 1m on both banks of Nhu Y river on the Southern bank of Huong River as can be seen in the Figure 7 below.

It can be seen that, since 2015 and in the following years, many investment projects for construction and enhancement of the drainage network of Hue city have been implemented in order to complete the drainage system, improve drainage capacity with the purpose of reducing flooding and environmental pollution in the city, strengthening the city's resilience in the context of climate change and sustainable development of Hue city. However, up to now, flooding has often occurred and hugely affected the lives and activities of local people. Frequent flooded areas on the Southern bank of Huong River include the followings [9].

Xuan Phu Ward is the most seriously flooded area. Due to the low natural terrain, almost the entire area is flooded when it rains. Recently, the ground of City Sports Center and Kiem Hue new urban area has been upgraded and the T7 canal on the extended section of To Huu street has also been built, so it has partly solved the flooding in the area. However, the urban area south of the City Sports Center towards Truong Chinh Street is still regularly flooded.

Vy Da Ward is often flooded when it rains and the water level of Huong River rises. The areas of Vy Da Secondary School, Nam Vy Da planning area and Tung Thien Vuong and Tuy Ly Vuong streets are usually about 0.5m under water after rain.

Phu Hoi Ward is often flooded at the beginning of Ben

Nghe - Hung Vuong, Pham Ngu Lao, Vo Thi Sau, and Tran Quang Khai streets. The level of inundation is about 0.5m and the water recedes 1-2 hours after the rain.

Vinh Ninh Ward: On Phan Boi Chau, Nguyen Thien Ke and Ly Thuong Kiet street, it is flooded about 0.3m in heavy rain due to the small diameter of the existing drainage pipe.

Phu Nhuan Ward: On Nguyen Hue and Nguyen Thi Minh Khai streets, the Nguyen Tri Phuong - Hung Vuong junction area is sometimes flooded due to small drainage pipes. This area is flooded by 0.2 - 0.5m and the water is drainedafter about 1-2 hours.

An Cuu Ward is partially flooded in a short period of time when it rains heavily in Kiem Hue, Kiet Mieu Doi.

Phuong Duc Ward is often flooded locally along Bui Thi Xuan and Duong Xuan Ha streets in a short time when there is heavy rain.

In addition, heavy rain causes flooding in many streets and underground parking places of some high-rise buildings such as SHB Building on Ly Thuong Kiet Street, buildings on Nguyen Van Cu Street, Big C supermarket, Hue City PoliceBuilding on Dong Da Street, etc.

3.4. Measures for improvement of operational efficiency of drainage network and increase of resilience for Hue city under climate change conditions

3.4.1. Consideration of additional parameters for design of drainage network

Up to now, the design of urban drainage system follows national codes, standards and criteria of the Vietnam Ministry of Construction in calculating the size and scale of works and based on systematic analysis of past rainfall events, in particular the frequency with which the rains cause flooding. However, climate change leads to an increased intensity and frequency of extreme rain events resulting in more frequent flooding. Therefore, the design criteria of urban drainage systems need to consider changes that may occur due to climate change. This includes calculating and reviewing information on (1) forecasts for extreme rainfall over the area under consideration; (2) the expected level of performance (or acceptable level of risk); and (3) the expected lifespan of the works. At the same time, the consideration also has to ensure efficiency of the investment cost to avoid wasteful investment.

3.4.2. Application of information technology

The application of software and measurement systems for flood warning has been a popular method applied in many countries around the world. In fact, to be able to provide better information on the possibility and extent of flooding, Hue City Government also needs to further study and invest in disaster prevention and forecasting equipment, measuring equipment with sensors should be equipped at key works such as rivers, ditches, ponds, lakes and in rainwater drainage pipes. Water level or rain measurement data will be transmitted to the Flood Control Agency for analysis, simulation and proposal of flood response activities. The results will be notified to the people through the software application on mobile phones.

For example, "Flood Alert" app has been used on smartphones to provide immediate local and neighborhood flood warnings in England and Wales since 2011 when these countries are regularly flooded, causing billions of dollars in damage. Or in Japan, B-Dash, which is a system that supports the operation of flood prevention equipment consisting of monitoring, measuring, collecting, analyzing and reporting information, has been researched since 2013 and so far, been put into use. In addition, since the 1990s, Osaka in Japan has also installed a dedicated Radar system to measure precipitation and provide information for people and authorities.

3.4.3. Approach to sustainable drainage solutions

Inundation in urban areas is mainly caused by the concreting of the ground in urbanization process, which severely reduces the amount of rainwater infiltration into the ground and flows into water receiving sources such as ponds, lakes, and canals. Much of the rainwater flows directly into the drainage system, causing overload and flooding only shortly after the rain begins. To solve this situation, Sustainable

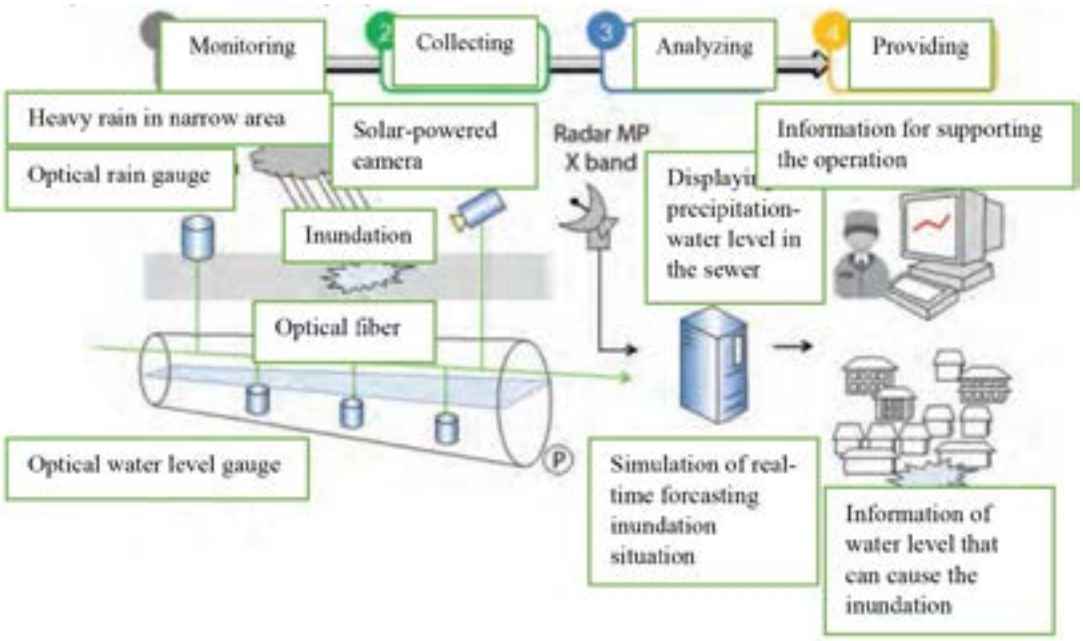

Fig. 7. Flood prevention system in Japan [14]

Fig. 8. Sustainable Urban Drainage Solutions - SUDS[15]

Urban Drainage Solutions (SUDS) – an integrated solution of structural and non-structural solutions is very suitable and necessary.

The principle of SUDS is directed towards maintaining the natural characteristics of the flow in terms of volume, intensity and quality, maximum control of runoff from the source, minimizing areas of direct drainage, storing water in situ and allowing it to seep into the ground, while controlling pollution.

Key benefits of SUDS include i) Resolving inundation; ii) Preventing water pollution and reduce environmental pollution in general; iii) Ensuring the harmony of the natural landscape, greening the urban area; iv) Ensuring habitat for wildlife, and v) increasing diversity etc.

According to a study by GIZ-Ministry of Construction in 2016 on building solutions with an interdisciplinary approach to flood control, researchers have come up with groups of works that have a positive impact on increasing energy urban flood resilience and adaptation that can be studied and applied in Hue city as shown in Figure 8.

On the southern bank of Huong River, there is a large system of key drainage works with such rivers as Huong, Nhu Y, An Cuu, Nhat Dong and Phat Lat, and drainage channels such as Moc Han, Ba Niem, Nhat Tri, etc. and the system of ponds and lakes. Therefore, in order to ensure effective drainage, large water storage area, air conditioning, and beautiful landscapes for the city, the City government should pay attention to upgrading the efficiency of these works through embankment, anti-subsidence banks, regular dredging, etc.

In addition, in urban areas as well as new urban areas of AnVan Duong, it is necessary to make careful consideration on the use of materials that allow water infiltration in large public areas such as squares, parks, and parking lots, and limit of concreting and providing more lawns, trees, lake surface, etc.

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Furthermore, like other provinces with hydroelectric works, the management of drainage in Hue city is more difficult because the operation of the reservoir would also lead to floods. The hydrometeorological monitoring equipment in the upstream area, equipment for warning, building and updating flood maps, and measures to ensure downstream safety are still very limited. Along with that, the operation, regulation and discharge of floods, as well as information on flood discharges of some reservoirs are still inadequate, making it difficult for response in the downstream area, causing huge damages. Therefore, inter-sectoral coordination in the operation of the drainage system is essential to minimize damage in the events of flooding.

4. Conclusion

The research results reveal that the drainage system on Southern bank of Huong River has been recently improved with aim to enhance the drainage capacity for urban areas via such project as the Japanese ODA funded project, ADB funded project or local funded projects. However, under the influence of climate change, the weather is becoming more and more extreme and the unseasonal rainfall is increasing, the sewer network is still not able to drain in time, causing flooding in many locations on the Southern bank of Huong River. In addition, according to the climate change scenarios, the annual average temperature in Thua Thien Hue province will increase by 1.9ºC and 3.5ºC for RCP4.5 and RCP8.5, respectively; and the annual rainfall tends to sharply increase 26-31% at the end of 21st century.

Therefore, in order to enhance capacity on prevention of flooding risks and effectively respond to climate change, a holistic and integrated approach is needed. Within the scope of the research, the authors propose a number of technical measures such as consideration of additional parameters in the design of sewers, use of flood warning software, and approaching sustainable drainage solutions to improve the management capacity of the drainage system, adaption to flood risks, minimization of damages to local people as well as ensuring the sustainable development of the City./.

Technical process of operation of bubbling...

(continued on page 67)

Make sure the meter or water level display element is working properly

Ensure the cleanliness of the filter installed at the pump suction

Make sure the pump surroundings are clean of foreign substances and no chemicals are spilled there, for safe operation purposes.

Periodically check the pump inlet pressure and the operation of the pressure reducing valve.

(20) Mechanical dust collector

Visually check to see if there is a leak at the mechanical dust filter output flange.

Check the corners of the ash hopper to see if there is a leak.

Assess the level of leak, if serious, plan to stop the incinerator earlier than usual for repair. Stopping early can reduce damage to the valves.

Check the temperature of the bearings, if high temperatures are detected use the recommended lubricant.

3.3. Procedure for stopping solid waste incinerators

Just like when starting the incinerator, the process of stopping the incinerator must strictly comply with the regulations stated in the National Technical Regulation on incinerators QCVN 61-MT:2016/BTNMT. At the same time, the operator needs to follow the basic steps shown in Figure 3.

Conclusion

Fluidized bed incinerator technology (BFB, CFB) to treatment domestic solid waste and convert it into energy is a modern technology that requires the construction of very strict and meticulous operating process. With 3 basic processes that have been detailed and clearly outlined by the research team for each level from starting, operating to stopping the incinerator, this will be the necessary content to proceed with the implementation of training for direct and indirect managers can apply it correctly in real-life conditions, ensuring the best operating efficiency of the incinerator system, following technical and safety procedures. Besides, the research results are also reference documents to serve in training and scientific research in the field of environmental engineering./.

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