

THE ASSESSMENT IMPACTS OF THE BACKFILL PROJECTS TO URBAN INUNDATION IN HO CHI MINH CITY

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Abstract

The new project of population locations, new industrial zone of Ho Chi Minh City and surrounding provinces, which are the backfill projects along the Soai Rap, Sai Gon Rivers, which are in Long An province and Ho Chi Minh City, have made the increasing of tidal water level on Sai Gon River (at Phu An hydro-meteorology station) to cause the inundation at many places, which are in Ho Chi Minh City. In the National University of Ho Chi Minh City's research frameworks, the assessment impacts of the new backfill projects along the Soai Rap–Sai Gon Rivers to increasing a tidal water level at Phu An hydro-meteorology station on Sai Gon River are implemented. The results of research have initially identified the relationship between the backfill areas with inundation status by tide in Ho Chi Minh City in current years. The paper will present the results of the assessment impacts research and give some recommendations about the management of urban using land plan.

Keywords: Inundation, river water level, tidal flooding, urbanize, impacts, Long An Province, HCM city

Introduction

Ho Chi Minh City locates in the Sai Gon River sub-basin, the North Mekong Delta, and be a seat of Southern States of France from 1862. Nowadays, with a population of over 10 million and 10% of the country's population, Ho Chi Minh City is a largest financial and economic center of Viet Nam. The urbanizing speed of Ho Chi Minh City is booming

compared to the rest of the country with a series of real estate projects, new industries combine river port appears. While many issues related to the management, but it not deny that all new projects have given the City a new appearance (Figure 1).

Besides the elements of good economic management, dynamic thinking of the managers

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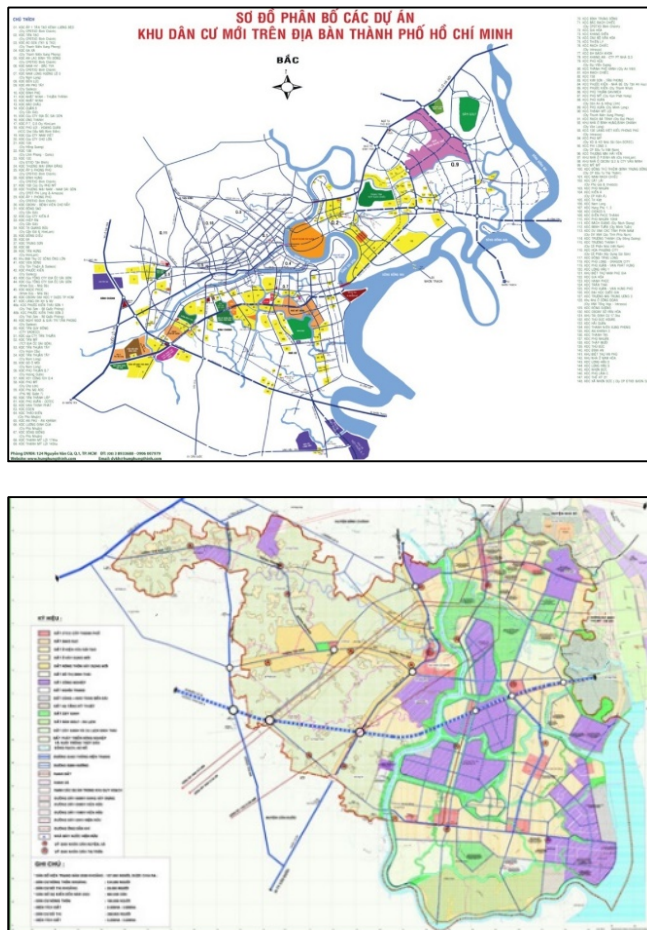


Figure 3. Locations of the new resident and industrial areas follow the development plan of Ho Chi Minh City and Can Giuoc district – Long An province

transshipment ports, ... We can mention a lot of the new residential areas, new industrial zones or new harbour along the Soài Rap River such as: (Figure 3)

- Long Phụng urban – industrial park (Can Giuoc resident – industrial area) with scal is 2611 ha, there are the industrial park (Tan Tap industrial park) with 1266 ha area, urbanization, commercial services with 1300 ha area.

- Bac Tan Tap industrial park (1000 ha area); Nam Tan Tap industrial park (266 ha area).

- Long Hau industrial park, which is planed and approved by agreement number 1107/QĐ-TTg date 21/08/2006 with 140 ha area and surface level +1.8 m.

The process of rapid urbanization of Ho Chi Minh City and neighbour areas have made rapid changes their faces to become model and development. But, besides their repid changing, the urban environment quality is decreasing. Such as: the quality of water, land and air being very low due to pollution from living and industry's wastewater, sewage. The natural canal and rivers have fillbacked for building new resident and industrial areas. There are many shadow, tidal ponds be fillbacked; the dyke systems have constructed to protect the new areas before tidal flood. These reasons combined with many others have been made the urban inundation at many places of Ho Chi Minh City. The flooding resident house, roads



Figure 4. Some inundation pictures on urban roads of Ho Chi Minh City

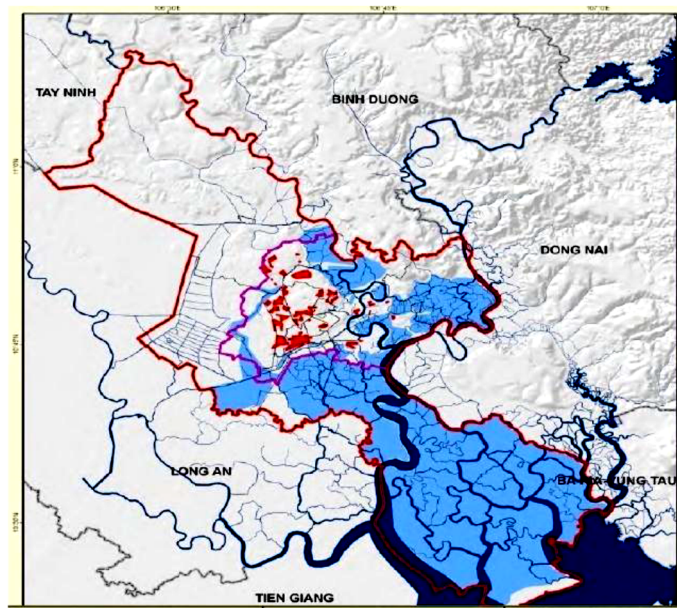


Figure 5. The usual inundation due to tide (green color), rain (red color) and the number of tidal flooding places in City's region

become normal in every time when have tidal flood or stormrain (Figures 4 and 5).

The reasons caused the urban inundation in Ho Chi Minh City, which are researched/ studied, evaluated very much. The main reasons identified by many projects and researchs of flooding prevention, which include natural and man sources. They are such as upstream flooding flow, rainfall, tide from sea, groundwater overexploited to cause the subsidence, shadow and tidal areas backfilled to build the new resident and industrial parks. Although, there

are many flooding prevention works to monitor tidal flow, upstream flooding flow, as well as the management, protecting state of river–canal system in Ho Chi Minh City, the results and effects are still very limited. The inundation situation is gradually become well in central City because most of flooding prevention works are doing with right designed missions. Oppositely, the inundation situation be at suburban areas is become badly and difficult. It causes the pressing on local community. Nowadays, the City has spend a

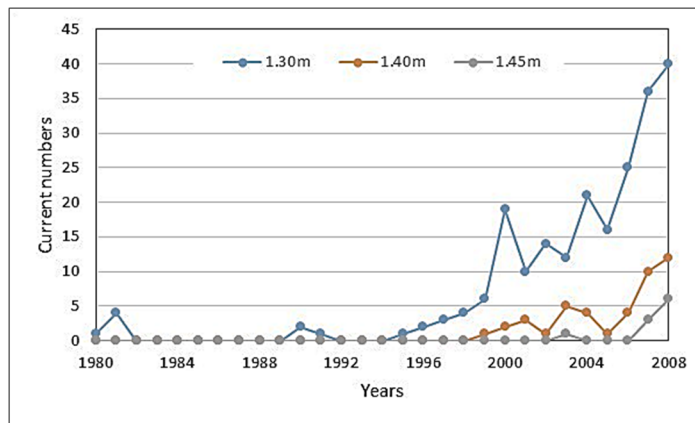


Figure 6. The hydro-stations in Dong Nai–Sai Gon River basin and The current number of high tidal levels 1.3 m; 1.4 m, and 1.45 m at Phu An hydro-station. (Source: Ho Long Phi, 2010)

lot of fund to construct many works to prevent the urban inundation (it is over 24.000 billion VND). But the inundation situation is still happened and has trend of increasing and serious. So that, the reasons caused inundation should studied detailly for identification of their primary characteristic.

For the identification of reasons caused a tidal inundation, there are many researches by the water resource institutes, relative organizations and professional consultants. Based on the research of National University of Ho Chi Minh City, which is about the backfill's influence to inundation situation in Ho Chi Minh City, the paper presents the results of research and make clearly the influence. Thereby, the tidal regulative functions of wetland arounded the estuary are very importance to prevent a tidal floods in City's region (Figure 6).

Results and Discussion

To identify the real causes of tidal inundation in the Ho Chi Minh City, we should review the transportation of channel and propagation of tidal flow.

Propagation of tidal flow into the Dong Nai River system. The tide impacted to Ho Chi Minh City is from East Sea and propagates into inland by Soai Rap River. Tidal flow make Sai Gon River's water level rised and overbanked to cause the flooding the shadow land areas.

Through a study of Le Ngoc Bich (1998), on Dong Nai River basin, then the tidal flows at the Estuaries are very large and diffrent (hundredes thousand cubic meter per second). The total average volume per day of the tidal maximum flow propagated into the estuaries of Dong Nai River system (April) is about $1.36 \times 10^9 \text{ m}^3$. Where: the volume of tidal water came in the Soai Rap River make up 22%, the Long Tau River about 59%, the Dong Tranh River about 3% and the other mouths of Cai Mep and small Rivers about 16%.

The tidal water propagated up the Dong Nai–Sai Gon River is about $211 \times 10^6 \text{ m}^3$. The tidal water comes from Soai Rap and Long Tau Rivers, which meet together at Nha Be Confluence River. According to Le Ngoc Binh (1998), in dry season, the upstream flow discharged to the East Sea by Long Tau River is usually larger than Soai Rap River about four time (at high tide) and tewlve times (at low tide). By the real hydraulic measurement at Mui Den Confluence River, the tidal part propagated into Sai Gon River is large and makes about 50–75% of total tidal volume.

The tidal water volume propagated up Dong Nai–Sai Gon River system has a primary role to the tidal flooding situation in Ho Chi Minh City, which is from the Soai Rap River (make 75% of the tidal volume propagated into the Dong Nai–Sai Gon River) and the Sai Gon River (50–75% the tidal volume on the Dong Nai–Sai Gon River).

Table 1. The level of tidal water increase (the 18 year range) at the hydro-stations in Dong Nai–Sai Gon River basin

No	Name of station	Mann-Kendall Z	Assessment status
1	Phu An	4.03	Strong increase
2	Vung Tau	-0.04	Not increase
3	Thu Dau Mot	4.46	Strong increase
4	Nha Be	3.27	Strong increase
5	Bien Hoa	1.86	weak increase
6	Ben Luc	3.88	Strong increase
7	Tan An	2.88	Strong increase

(Source: Ho Long Phi, 2010)

Besided on the analysis of the hydro-shapes and upstream flows, the tidal propagation role of Soai Rap, Sai Gon Rivers and the impacts of backfill projects to the tidal regime in Ho Chi Minh City are emphasised by the assessment of variable tidal water level at the hydro-stations in Dong Nai–Sai Gon River basin.

In amount of 7 hydro-stations in Dong Nai–Sai Gon River basin, the variabilities of tidal water level measured at Phu An and Thu Dau Mot hydro-stations, they are on Sai Gon River, are strongest. Additionally, the variability of tidal water level are strong increase at the hydro-stations side Soai Rap and Sai Gon Rivers (Phu An, Thu Dau Mot, Tan An, Ben Luc, Nha Be) and weak or not increase at hydro-stations side Dong Nai River (Bien Hoa, Vung Tau). Especially at Phu An hydro-station, the occurent number per years of high tidal water level (1.3 m, 1.4 m, and 1.45 m) have the increasing trends. (Ho Long Phi, 2010) (Table 1).

The effects of aggrades at the tidal flooding areas to cause the enhancement of tidal water level at Phu An hydro-station. When the shadow/tidal areas have been aggraded and protected by the closed dyke system prevented the tide floods for the development of new resident and industrial parks, the tidal flow not be regulated along river (the tidal flow concentrates only on main channel). It causes the tidal flow to propagate deeply into inland and tidal water level to rise higher. Due to the tidal water level rised higher and the tidal flow propagated more far, there are many locations with high surface level and locates far from river which are flooded by tide in dry season.

The local resident livings and production are impacted adversely in the region.

For the assessment of impacts of the backfill projects located at a floodplain and tidal areas be along the Soai Rap and Sai Gon Rivers to the urban inundation by tide in dry season in Ho Chi Minh City, we research and identify the changing of water level at Phu An hydro-station on Sai Gon River, as well as, we evaluate and measure the inundation area at some locations of Ho Chi Minh City when has the above projects before and after.

For the implementation, we use MIKE FLOOD hydraulic model to simulate the flooding of tidal flow in Dong Nai–Sai Gon River system. It can show the changings of water level of Sai Gon River at Phu An hydro-station according to the different computing options. We use the DEM of Ho Chi Minh City in year 2005 combined with water levels on rives, cannals and streams to fine and measure the inundation area. The present hydraulic condition of option 1, we use the hydraulic regime of Dong Nai–Sai Gon River system with the tidal water level +1.40 m at Phu An hydro-station.

Ho Chi Minh City has many projects/plans of the resident and industrial parks along Sai Gon River and Nha Be River (Figure 3). Also, the region, along Soai Rap River, has many integrated projects included resident, industrial and habour functions. They are belonged Long An province and especial Can Giuoc District (Figure 3). Most of them (backfill projects) have been completed an aggradisement works (surface rised over the maximum river water level).

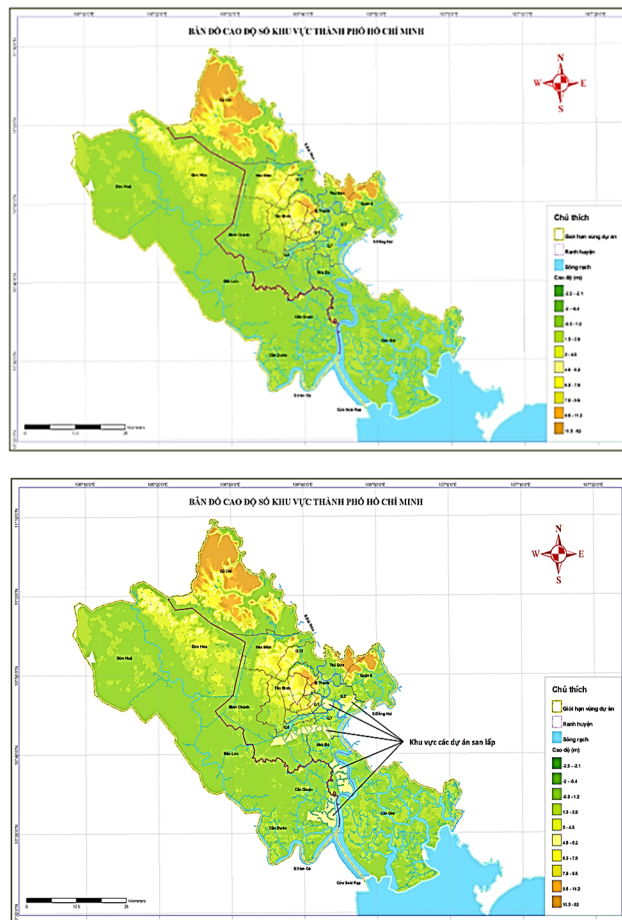


Figure 7. The DEM in year 2005 for present condition of option 1 and other options with the backfill projects

The backfill projects have used in the computing model MIKE FLOOD in Ho Chi Minh City such as: Nam Sai Gon new city with 2975 ha; Hiep Phuoc new city – industrial park with 3911 ha; Thanh My Loi city with 322 ha; Binh Trung Dong new city with 154 ha; Thu Thiem new city with 737 ha; Hiep Phuoc new city – industrial park – exporting harbour with 3911 ha. There are Long Phung new city – industrial park with 2611 ha in Long An province (Figure 7).

Based on the progress of implementation, we have divided it to become four periods according to four computation options such as: (Table 2)

From the computation results of all options,

we can withdraw some indentifications to make clearly the relationship between the backfill projects and the changings of tidal water level of Sai Gon River at Phu An hydro-station. They are such as:

The relationship between the enhancement of backfill projects and the tidal water level on Sai Gon River. To identify the relationship between the changing of tidal water level on Sai Gon River and the enhancement of backfill projects along Soai Rap and Sai Gon Rivers, we applied the tidal regime at Vung Tau for all computation options (Table 2). And the results are showed on below Table 3.

It is clear that the backfills at tidal flooding areas and floodplain effected very

Table 2. Table of the computation options

No	Option	Project name/total area (ha)	
1	Present	DEM 2000	
2	Case 1 of Option 1	Nam Sài Gòn	2,975
3	Case 2 of Option 1	Nam Sài Gòn; Hiệp Phước	6,886
4	Case 3 of Option 1	Nam Sài Gòn; Hiệp Phước; TML+BTĐ; Thủ Thiêm	8,099
5	Case 1 of Option 2	Nam Sài Gòn; Long Phụng	5,586
6	Case 2 of Option 2	Nam Sài Gòn; Hiệp Phước; Long Phụng	9,497
7	Case 3 of Option 2	Nam Sài Gòn; Hiệp Phước; TML+BTĐ; Thủ Thiêm; Long Phụng	10,710

Note: Option 1 – it includes only the backfill projects in Ho Chi Minh City; Option 2 – it adds the backfill project of Long An province into the above Option 1.

Table 3. Table of tidal water level according to options at Phu An hydro-station

N	Option	Project name/total area (ha)	Water level (m)
1	Present	DEM 2000	+1.550
2	Case 1 of Option 1	Nam Sài Gòn	+1.555
3	Case 2 of Option 1	Nam Sài Gòn; Hiệp Phước	+1.575
4	Case 3 of Option 1	Nam Sài Gòn; Hiệp Phước; TML+BTĐ; Thủ Thiêm	+1.590
5	Case 1 of Option 2	Nam Sài Gòn; Long Phụng	+1.565
6	Case 2 of Option 2	Nam Sài Gòn; Hiệp Phước; Long Phụng	+1.605
7	Case 3 of Option 2	Nam Sài Gòn; Hiệp Phước; TML+BTĐ; Thủ Thiêm; Long Phụng	+1.615

Note: Option 1 – it includes only the backfill projects in Ho Chi Minh City; Option 2 – it adds the backfill project of Long An province into the above Option 1.

large to the changing of tidal water level on river. Therefore, it resulted the enhancement of flooding area in Ho Chi Minh City. When the area backfilled of tidal region and floodplain along river increases gradually, it make the tidal water level also increased with the rate of **1 cm per 1200 ha** backfilled area (Figure 8).

The effect of the backfill projects of Long An Province and suburb Ho Chi Minh City are stronger. Because they impacted directly to the tidal flow on Soai Rap River. They made the tidal water to flow up quicker and not loss much energy and volume. So, the tidal contribution of Soai Rap River for the Dong Nai–Sai Gon River is larger and stronger. For the identification of the above recognition, we compared the computation tidal water levels of option 1 and option 2. They are showed as below Figure 9.

We have recognize that the impact of the backfill projects of Long An province is stronger than Ho Chi Minh City's ones. When Long Phung backfill project added into the computation option (option 2, case 2, and 3), the water levels increased quickly and made the trendline of option 2 be more sloping. The rate of increase is about 1.5 time.

Based on the simulation of tidal flooding on Dong Nai–Sai Gon River basin, we have measured the flooding area of Ho Chi Minh City when the Sai Gon River's water level is changed at Phu An hydro-station from +1.0 m to +1.6 m. Thus, the relationship between the flooding area and the tidal water level on Sai Gon River is showed as the above Figure. Generally, the rate of flooding area is 3.45 km² when tidal water level rised 1cm at Phu An hydro-station. The flooding area locates on

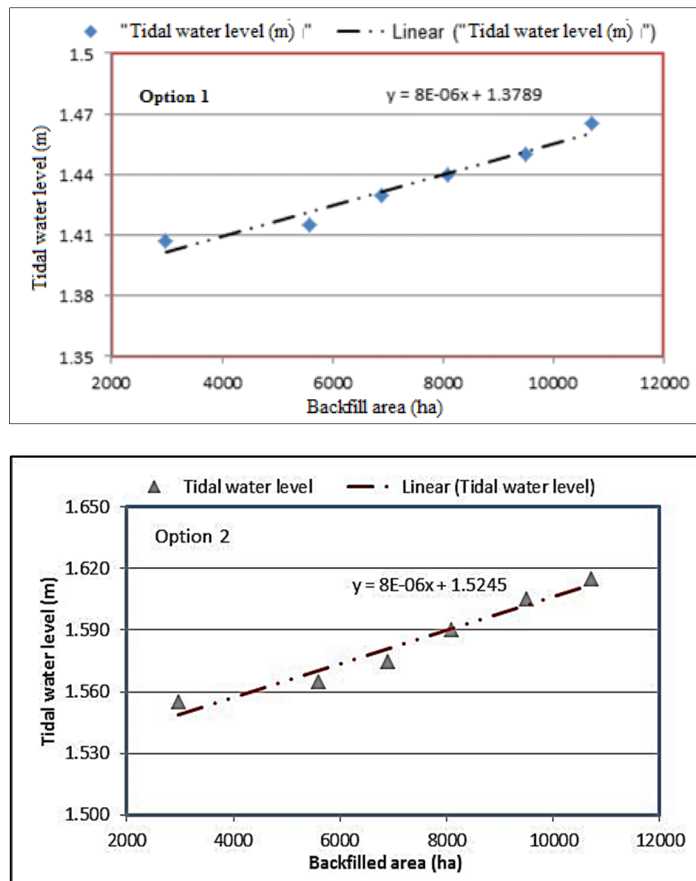


Figure 8. The relationship between the backfilled area and tidal water level on Sai Gon River of option 1 and 2

some shadow districts of Ho Chi Minh City such as Binh Chanh, Nha Be, Can Gio, Thu Duc, Binh Thanh, District 2, District 4, and District 7. Which are as the green color region of Figure 6.

The effect of backfill projects to the enhancement of inundation situation by tide in dry season. Visually, the flooding area (violet color) on the below figures expanded and be bolder when tidal water level at Phu An hydro-station increases to +1.3 m, +1.4 m, +1.5 m and +1.6 m (Figure 10).

For more clear identification of the relationship between the backfilled tidal flooding area along river and the increased inundation situation in Ho Chi Minh City, we measured the inundation area in Binh Thanh District of Ho Chi Minh City referred to the

each level of backfilled area. The relationship between the flooding area and backfilled area is showed on below Figure 11.

The flooding area of Binh Thanh District is increased about 1% area (20.8 ha) when the backfill area add more 1000 ha.

Each district of Ho Chi Minh City has different topography and slope surface, so, their flooding rates are also different. Briefly, we account their flooding area according to the tidal water levels for the City. Its relationship is showed as below figure. And the flooding area of Ho Chi Minh City is increased about 3350 ha when the backfill area add more 1000 ha. In the case, the districts flooded completely are Can Gio, Nha Be, Binh Chanh and the part of districts flooded are the remain of Ho Chi Minh City.

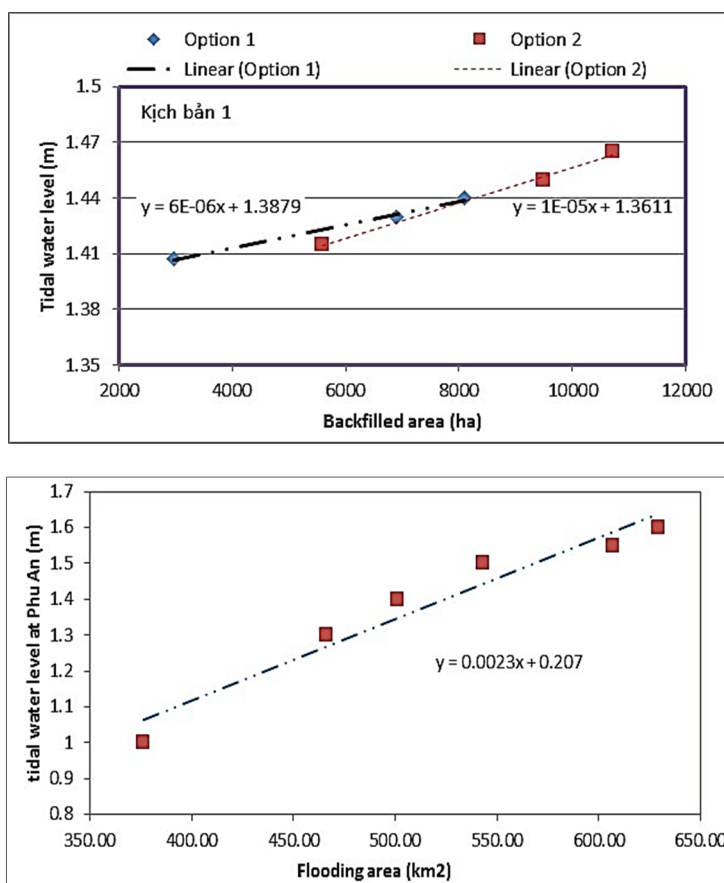


Figure 9. The difference of effects between Option 1 and 2, and the relationship between flooding area and changing of tidal water level on Sai Gon River

The important regulative function of wetland near river. By the qualitative side, we understood clearly that the tidal influence of “upstream” Soai Rap River to the tidal volume propagated up and water level on Sai Gon River is very strong and further than Long Tau River. The tidal flow follow Soai Rap River is primary cause to enhance the tidal volume propagated into Ho Chi Minh City to cause the tidal inundation situation in dry season. The primary causes to explain this recognition of the tidal water level enhancement on Sai Gon River in Ho Chi Minh City, which are the hydro-shape of channel and the upstream flows (from the Tri An and Dau Tieng reservoirs). Although, we not yet have an analysis carefully about the hydro-shape channel factor, but this

factor is extremely important by the brief evaluation of flows on Soai Rap and Long Tau Rivers.

Additionally, we can see that the floodplain area’s role is primary function to disintegrate the energy/volume of tidal flow on a river. When tide make, it causes a river water level to rise. The tidal flow usually divides to two parts when the river water level higher top level of river bank. One part, be on river, propagates continuously up the higher location, and other overbanks into the floodplain/shadow places near a river. So that, a part of tidal volume and energy is kept at the wetland/floodplain. A residual tidal volume/energy be on river which is very less and weaker compared with before. Long Tau River

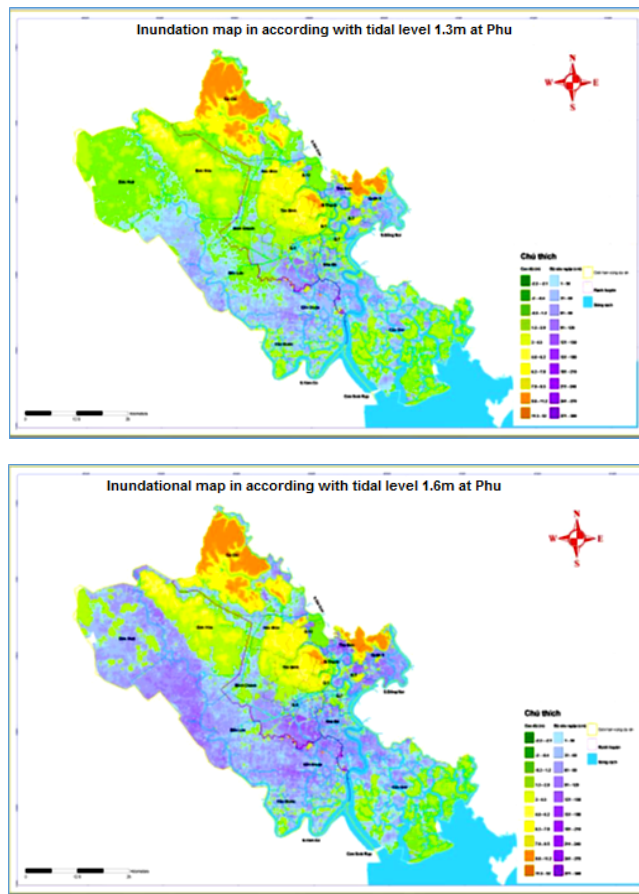


Figure 10. The changing of flooding area according to the increases of tidal water level.

passes through the Can Gio mangrove forest, which is shadow large wetland. Most tidal volume comes in Long Tau River's mouth which is overbanks into the Can Gio region and kept at there. So, the residual tidal volume of Long Tau River, which propagates up the Dong Nai–Sai Gon Rivers, is less than Soai Rap River's one. This is a secondary research results, when we demonstrated the influences/impacts of backfill projects along rivers to the changing of water level and the inundation situation in Ho Chi Minh City.

Therefore, the inundation situation caused by tide in Ho Chi Minh City will resolved or mitigated, if we kept to not backfill or remain the wetland/floodplain along Soai Rap and Sai Gon Rivers.

The impacts of backfills along Soai Rap and Sai Gon Rivers to the inundation situation

of Ho Chi Minh City by tide in dry season. The research has demonstrated the relationship/impacts between the backfill projects, which are along Soai Rap and Sai Gon Rivers, and the tidal water level at Phu An hydro-station on Sai Gon River. Initially, we have computed the increasing rate of tidal water level correlating with the enhancement of backfill area at the floodplains. The rate is 1 cm of increasing water level when the correlative backfill area added about 1200 ha.

Similarly, we also made clearly that inundation situation of Ho Chi Minh City is caused by the enhancement of backfill projects along Soai Rap and Sai Gon Rivers. The rate is 1000 ha backfill area to cause 20.8 ha flooded area of Binh Thanh District and 3350 ha flood area of whole City.

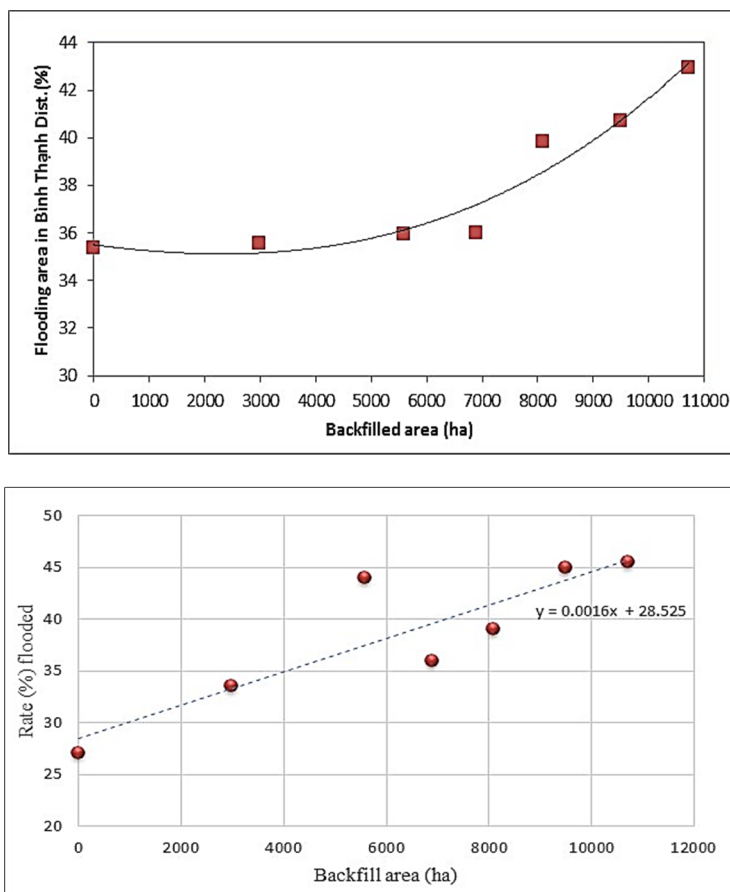


Figure 11. The increases of flooding area in Binh Thanh District. And the increases of flooding area in HCM City

The levels of influence/impacts of backfill projects located in Long An province and Ho Chi Minh City area different. The level of influence/impacts of backfill projects along Soai Rap River belonged Long An province is higher 1.5 time compared with others. So that, we see that the influence/impacts of changing of floodplain at the Soai Rap River mouth is large and sensitive. If we applied the construction methods as the daily regulative reservoir for tidal flow at the estuary of river, which like upstream reservoir to prevent flood for low basin, controls the tidal water level at any location along river. Thus, the inundation situation will solved completely.

The role of urban management. The urban management of land use issue is very important in City. The implementation of land

use plan of City has to monitor closely and manage concretely. Especially, the new projects included backfilling component have to review and evaluate their impacts to urban environment, water resource and identify that they are accorded to the land using plan of City or not.

It should have the monitoring method and control a situation of wetland/floodplain area along urban rivers. It should use/apply the new and effective management model/tools such as GIS, digital maps for the monitoring and evaluation of implementation land plan.

It should enhance the capacity of urban managers by the capacity building training.

The cooperation of tidal flooding prevention. Based on the different impacts of the backfill projects along rivers between Long

An province and Ho Chi Minh City, we emphasis that the inundation situation of Ho Chi Minh City caused by tide will soluted or mitigated, if there are the cooperation of management/method between the relative regions such as Ho Chi Minh City, Long An and Dong Nai provinces.

Conclusions and Recommendation

The research has been elucidated the effects/ impacts of backfills at the floodplains, shadow area and wetland along and near rivers to the enhancement of tidal water level on Sai Gon River in years. Additionally, it also found the relationship between the increasing backfill area and the enhancement of tidal flooding area in Ho Chi Minh City. Many locations of Ho Chi Minh City with high level is unflooded before, but now they are flooded by tide in dry season.

The construction of monitoring tidal works in Ho Chi Minh City which not yet solve completely the inundation situation by tide. So

that, the City should need and cooperate with the nearby regions, especially the tidal upstream regions such as Long An, Dong Nai provinces.

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