NATURE-BASED SOLUTION FOR FLOOD MANAGEMENT
AT NONG SUA DISTRICT, RANGSIT CANAL, THAILAND

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Abstract—The Nature-based Solution is inspired and supported by nature and use, or mimic, natural processes to contribute benefit back to ecological process and water cycle by improved management of water. A concept of “Room for a river” is one of nature-based solution for water management to be examined at a Nong Sua district, Rangsit area with 1,738 Rai. The study area existed for 100 year with irrigation canal systems in order to distribute water for farmer. In addition, this area has traditional furrow for orange farm and changed to palm oil instead due to plant phytopathy. In 2011, the great flood occurred in Thailand; the Rangsit area had not much damage. The objective of present study is to quantify the effectiveness of a high water channel concept for flood management for crisis water operation and management in the area.

High water level concept is applied can control amount of diverged water in furrow while traditional flood pain cannot. The Nature-based Solution for high water channel was quantified by conducting modeling approach with MIKE 11. The hydrodynamic flow and effectiveness of the capacity of the furrow area for water storage is determined in Western Raphipat canal during peak water level in October 2016. The storage capacity of furrow was computed and estimated to be 753 m³/Rai or 1.3 MCM. The computational results showed that diverting water from Western Raphipat canal into Rangsit community area reduced peak water level 34 cm same as recorded one. The model is then used to optimize nature based solution extending concept to nearby area and increases inflow. It is proved that the nature-based solution for high water channel can be applied in district without any new construction of flood control structures.

Keywords —nature-based solution; high water channel concept ; flood management ; acidity soil.

1. INTRODUCTION

Nature-Based solution (NBS) for water is natural processes to cost effectively contributes to improved water management. Natural ecosystem can be used and proactive in term of rehabilitation, conservation or even creation of natural processes in modified ecosystem, even mimic the natural process [1]. NBS can address and improve water availability, water for agriculture, urban water, water quality and reduce risks to water related extreme events. Netherlands initiated their “Room for the River” (RFR) programme to restore natural floodplains of river along certain non-vulnerable stretches, and creating water storage area. The concept of co-benefit of NBS is introduced to substantial value in social, economic and environment. NBS for water management have also high potential to contribute to the achievement of SDGs.

When the amounts of water come over the capacity of the stream or river, the overflow occur and lead to inundation. The goal of the room for river concept is to provide the space to be able to carry and manage high water level (roomfortheriver.nl, n.d.). According to Reference [2] in Netherlands, the concept room for the river was planned with the goal to protect the 4 million inhabitants of the river catchments from high water level. The program was considered a national and international example for integrated flood risk management and multi-level governance. However, every river has the different and requires a proper solution to apply the concept. Fig.1 shows the ways how to make room for the river. Nevertheless, the room for the river concept can be the non-structural measures to reduce and mitigate the damages from flood hazard.

A high-water channel as shown in Fig. 2 which a type of RFR, is a diked area that branches off from the main river to discharge some of the water via a separate route (roomfortheriver.nl, n.d.). The channel is not excavated below the water table but rather formed by building two dykes in the landscape. According to Reference [3], the project of the Flood Channel Veessen-Wapenveld in Netherlands, the project is one of the measures, which provides better flood protection for areas near the country's rivers. The high-water channel is located between Veessen and Wapenveld, 15 km to the south of Zwolle. It is used only when water levels reach extreme highs, water level in the IJssel River is reduced by 71 cm (ruimtevoorderivier.nl, n.d.). This is a once in a lifetime event. The rest of the time, as now, the area can be used for farming. The channel will not be dug out, but formed by building two dikes measuring approximately 8 km. Fig. 3 shows example of high water concept. The retention area or basin is used to manage storm water runoff to prevent and collect flooding in order to protect downstream from inundation and erosion, and improve water quality in an adjacent river, stream, lake or bay.

Concept of RFR is quantified to reduce flood risk in Rhine and Meuse rivers under extreme events [4]. By increase of width of river, results in reduce exposure of flood by less economic damage and casualties. The degree of reduced flood risk by lowering water level in river not only depends on reduced consequences, but also probability of flooding. It is recommended that flood protection (embankments) combined
with flood mitigation (lowering flood level) is thus the more flood risk management strategy.

\[ \text{Increase discharge} \]

- Removing obstacles
- Deepening the river bed
- Lowering permeable gravel and building retaining gravel

\[ \text{Divert water} \]

\[ \text{c. Room for the river for divert water} \]

Fig. 1 How area will make room for the river.
Source: (roomfortheriver.nl, n.d.)

Fig. 2 Operation of high water channel.
Source: (roomfortheriver.nl, n.d.)

Fig. 3 The project of the Flood Channel Veessen-Wapenveld in Netherlands.
Source: [3]

Flood management in California have showed that setting levees back from river in several locations provides the most effective method of reducing local flood risk. It restores large land for floodplain habitat. The US Army Corps of Engineers found that acquiring and protecting floodplain wetlands can reduce Boston’s flood risk from that Charles river for 1/10 cost of plan that introduce new engineered infrastructures [5]. Evaluating of flooding to ecosystems can be conducted through framework for both benefits and losses [6]. Flood can work as nutrient cycling function i.e. transfers of nutrients and organic matter between floodplain and rivers. Indicators for assessing change in ecological conditions are proposed.

The studies or projects of the retention or detention areas often concentrate for applying the area to store water for the same purposes. The main objective of them is to enhance and manage the area to keep the amount of water in order to protect or prevent downstream areas from flood risk and also to solve the drought. To mitigate floods in the lower Chao Phraya River Basin (CPRB) in Thailand, the setup of flood retarding areas in paddy cropping areas is one of the control options [7]. Their hydrological effect and economic impact are explored. The results show that the rice flood retarding area can reduce water level in the river at the storage and the downstream points. Moreover, the frequency of flood volume distribution shows that the existing retarding volume (1,738 MCM) is enough to store flood volume occurred 12 in 24 times during 1952 – 2011 period. Cost effectiveness analysis shows that overall increased storage in retarding area reduces damage cost downstream. The guideline for floodplain management is studied for water depth in floodplain (0.40, 0.80, 1.00 m) and effective in reduced water level in Chao Phraya river [8].

In addition, Rangsit canal as the main line which feeds inhabitants, it is a valuable water resource for cultivation, transportation covering consumption, even if the function as irrigation canal is decreased by industrial; in fact, Rangsit canal is continuously supporting the people as a proficient drainage and irrigation canal from the past until now [9]. Rangsit field is an agricultural area for a century before it is adapted to water diversion area without the pre-evaluation of the impact assessment, but the area has the satisfactory potential to perform its duties. Plan to reduce flood risk in Bangkok is to divert the amount of water through the northern and eastern field of metropolis toward the sea in the southern part. The water is diverted in the northern and eastern field come from Pasak river and flow along the Raphiphat canal. This will divert water into the downstream area via Rangsit field and Rangsit canal. This plan was conducted in 2011. Due to large discharge in Raphiphat canal, the flood occurs. The Rangsit community protect the disaster of the huge flood by allowing for the amount of water pass through the area and build dikes along the canal to protect the agricultural area [10]. Another achievement is in October 2016, the communities open the regulators to turn the area into retention area and high water channel concept, which substantially reduce the water level in Raphipat canal because of the effect from the storm.

The objective of present work is to study of a Nature-based Solution for water management for high water channel concept in Rangsit area, Nong Sua district in Phatum Thani, Thailand.

II. METHODOLOGY

The study area is one part of the Northern Rangsit Irrigation project of the main project in the Southern Pasak covers 3 provinces Ayutthaya, Saraburi and Phatum Thani. The Southern Pasak project locate in Lower Eastern Chao Phraya river basin. The flow regime of the Southern Pasak and study area show as Figs.4 and 5. Flow direction is from north to south and then distribute in Northern Rangsit Irrigation project. Table 1 summarized capacity of canals and regulators.

As the purpose study is focused on the application of agricultural areas to store the amount of water by cooperation in the community to encounter the flood. Hence, the sub-district namely Bueng Cham Or in Nong sua district, Phatum Thani province, Thailand is selected as study area. Rangsit
The canal community is located in Nong Sua district, Pathum Thani province by the Chao Phraya river basin with a total area of 54.48 km². Figs. 6 and 7 shows study area While 44.16 km² have been used for agricultural production. The population is 8,926 people. Land use is summarized as follows: 19.63 km² (44.5%) of agricultural land for fruit crops - perennial plants, 18.30 km² (41.44%) for rice fields, 5.20 km² (11.8%) for vegetable crops and only 1.03 km² (2.33%) for farm crops [10].

Fig. 4  Flow regime of Southern Pasak project

Rangsit canal is used for supporting the agriculture for a century since 1980 and continuously improve the potential of distribution water for irrigation until present time. For decades, communities living along Rangsit canal searched for ways to improve their livelihoods. In 1984, the communities change their farmland into the orange orchard, but an outbreak of the citrus disease and acid soil put the farmer into debt [10]. Thus, farmers turn to cultivate oil palm. The plant has a good resistance for acid soil and inundated area, which started to boost income to them. However, a lack of water due to the poorly maintained and shallow canal challenged palm oil cultivation. In addition, the severe flood of 2011 also revealed other challenges including canal bank erosion. Fig. 8 shows photographs of canals in the study area. HAII encouraged Rangsit communities to establish a CWRM committee to apply the use of science and technology (S&T). Analysis of the water balance and the design and implementation of a new water resource management system to provide water for palm oil cultivation area were conducted.

Fig. 5 Flow regime of study are

Table 1 Capacity of canals and hydraulic structures
(Northern Rangsit Irrigation project, 2017)

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Type of structure</th>
<th>Maximum Discharge [m³/s]</th>
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<tr>
<td>1.</td>
<td>Phra Nakhon</td>
<td>Gate</td>
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<td>2.</td>
<td>Raphiap</td>
<td>Canal</td>
<td>17.000 - 235.00</td>
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<td>3.</td>
<td>Phra Nakhon</td>
<td>Gate</td>
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<td>Phra Nakhon</td>
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<td>5.</td>
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<td>Phra Nakhon</td>
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<td>21.</td>
<td>Rangsit Prasat</td>
<td>Canal</td>
<td>45.00</td>
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In addition, the NBS are applied in the area which is the concept for the mutual benefit of retention area and room for the canals. The main canals and sub-canals are dredged and linked with improved floodgates to maximize the water reservoir and drainage system. The water reservoir area is improved by vegetable patches around palm oil groves. A Suction Dredger Vessel, bought by Community Oil Palm Funds, diverts flood water to monkey cheeks (retention ponds) or furrows in palm oil patches and opens new waterways to agricultural areas in the dry season [10]. However, during the rainy season in August to October, the full bank flow occurs in Western Raphipat canal since it works as a diversion to bypass water from the Pasak river. One dimensional model is developed to simulate diverting water in Western Raphipat canal into the provided area using MIKE 11 model. However,
the model which obtained from HAI is the model for the Lower Eastern Chao Phraya river basin which is quite big domain. Thus, the domain in this study is deducted to simplify the model and make the model domain suitable for the study area. Furthermore, a model from HAI has only the components in flow river network then the model need to add the storage component for use to simulate the diverting water to flood retention area. The model simulates flow in the river from Raphipat canal which receive water from Chainat-Pasak and Pasak river into the study area in North Rangsit operation and maintenance project. The boundary conditions consist of:

1. Upstream boundary condition use the historical discharge data from Phrasrisin regulator and Phrasrisawapak regulator in Raphapat canal,
2. Downstream boundary condition use the water level data from Phra Intra)cha regulator, Middle Rangsit regulator and Chulalongkorn regulator, and the discharge from Phra Thamaracha regulator, and Q/h relationship for downstream of Klong 1 to Klong 12 as shown in Fig.9.

III. RESULTS AND DISCUSSIONS

Furrows systems in study area are shown in Fig 10. Its connection to sub-canals, drainage canals and Western Raphipat canal is shown in Fig.11. Their function is similar to retention storage. The furrow storage capacity in Rangsit area is estimated by using furrow cross-section multiply with total length of furrow in the study area to be 753 m³/Rai or 1.3 Million Cubic Meter (MCM). The model simulation has two conditions. First, the condition that simulates the river system in normal operation to show the stage of the canal in the normal situation. This is calibration and verification conditions. The second condition is the crisis operation which is the regulators gate opening were increased to receive water into area, and the artificial storage was added into model to be a flood retention. Results of model calibration using data in 2014 and verification in 2015 are shown in Figs 12 and 13. Correlation Coefficients for both results are 0.910 and 0.810 respectively. Bed resistance roughnesses are from 0.0035 to 0.025. Detail can be found in [11]. The crisis situation on October 2016 make the Western Raphipat had high water level more than 90% of maximum level of the canal on 13th October 2016. Therefore, HAI collaborated with Rangsit operation and maintenance project and Rangsit community to increase gate opening of Klong 7 to Klong 10 drainage canal head regulator. Water level at Western Raphipat canal reduced 34 cm within
half a Day in Fig. 14. The water diversion can protect water overflow due to dike repairing in Bueng cham Or area during that time. The concept of the crisis operation on 13th October 2016 is to receive water from Western Raphipat canal into drainage canal 7 – 10 and then water level in drainage canal will rise and flow into furrow by opening the farm turnout. Model results are shown in Fig.15. Computed results show that discharge flow into the storage 4 times on 14th, 18th, 22nd and 26th October with the value around 0.35, 0.22, 0.43 and 0.51 m$^3$/s respectively.

Furthermore, the inflow that flow into the storage are kept and made the water level rise from +1.75 m.MSL in the beginning to +1.771, +1.783, +1.799 and +1.818 m.MSL respectively which increase the water depth from 50 cm to 68 cm, or the volume from 509,000 m$^3$ to 577,000 m$^3$. In order to assess the maximum capacity of storage, furrow capacity is increased in the nearby area, i.e. Bueng Ka Sam. The present storage at Bueng Cham Or, 1.3 MCM can be increased 1.0 MCM to have total furrow capacity as 2.3 MCM. Results show that increased in the water depth in furrows from 50 cm to 55 cm, and the volume from 848,333 m$^3$ to 940,000 m$^3$. Crisis operation can be improved to store more water in furrows by increasing inflow in Klong 8. The discharge is increased by 5%, 20%, 50% and 80% of discharge after 13th Oct 2016 in Fig. 16. Water level in West Raphipat canal is reduced and storage in furrows system increase as shown in Fig. 17 and 18. Water level can be reduced from 34 cm to 52 cm and storage can be increased as high as 1.1 MCM. Therefore, furrow areas are adapted to be the retention storage to keep the water which has no damage occurs in the area.

![Fig. 11 Typical cross section of connection between furrows and canal](image1)

![Fig. 12 Water level at Western Raphipat canal station in 2014](image2)

![Fig. 13 Water level at Future Park station in 2015](image3)

![Fig. 14 Reducing water level in Western Raphipat canal on 13 October 2016, Source: (HAI, 2017)](image4)
IV. CONCLUSIONS

The application of a Nature-based Solution (NBS) for water management is successfully implemented in the Rangsit area to adapt the existing environment, and enhance the potential use of furrows system. Storage in furrows and irrigation canal, contributes for crisis management to reduce water level from main canal, Western Paohipat, so that the present flood diversion for Bangkok can be operated as its planned. Maximum operation can be achieved by extend furrow concept to nearby area and to increase utilization of furrows storage.

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