URBAN DRAINAGE SYSTEM, URBAN AGRICULTURE AND SWAMP RETENTION DEVELOPMENT IN PALEMBANG CITY

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ABSTRACT

In 2018, Palembang was experiencing a series of heavy rainfalls which caused a serious inundation on several parts of Palembang City. This inundation problem was caused by several triggers, i.e. exceptionally high rainfall intensity, insufficient capacity of urban drainage system to store the runoff, and weak operation and maintenance of urban drainage system (routine).

As the capital of South Sumatra Province, this situation needs to be improved. In this research besides hydrological and hydrodynamic analysis of the urban drainage system, several possible measures were checked. In this case, besides checking the capacity of the urban drainage system, two measures related to the urban agriculture and utilisation of the swampy areas which can be used as storage areas with two important functions which is first to store the runoff during heavy rainfall and second to serve as raw water resources during the dry season.

In this particular measure, two areas were analysed i.e. Gandus and TalangKepu in order to control the runoff in Lambidaro area. The correlation curves between storage area of the swamp retention basin against the outlet capacity are presented and will be an important consideration for the decision makers. Besides as an important measure to control runoff, the conservation of the swampy areas needs to be maintained and urban agriculture is one of the possible measures to overcome the urban flood as well as to optimize the use of runoff water. On the other hand, (routine) operation and maintenance of urban drainage system that included pumping stations and river systems in Palembang City needs to be improved.

Keywords: Urban flood, conservation swamp, river restoration, inter basin transfer, urban agriculture

1. INTRODUCTION

Located about 100 km from the estuary of Musi River, Palembang City gets dominantly influenced by tidal fluctuation in the Musi River. Many areas in Palembang are below the Musi River high water level due to high tide in the wet season that results in the area prones to flood. Most of the areas in Palembang is in depression and swampy areas, so that without a proper drainage system these areas are subjected to the inundation due to the rainfall. It is a challenge for Palembang which has programme to improve the performance of the city as an interesting, safe and a beautiful and attractive waterfront city with the improved urban drainage system in Indonesia. For this purpose, Municipality of Palembang needs to improve the urban drainage system in Palembang City.

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Several strategies both structural and non-structural are proposed to overcome the flood and inundation problems in the Palembang City. Structural measures include the installation of water control structures and pumping stations, the proper operation and maintenance of urban drainage system, normalisation of the main urban drainage system, and also setting up levee and dike system. The efforts taken should be environmentally sound and involve the society and all the related stakeholders. In this paper, an option to apply swampy areas for flood control as temporary storage is discussed.

Palembang City has 21 river basins which will influence the urban drainage system and conditions as shown in Figure 1.

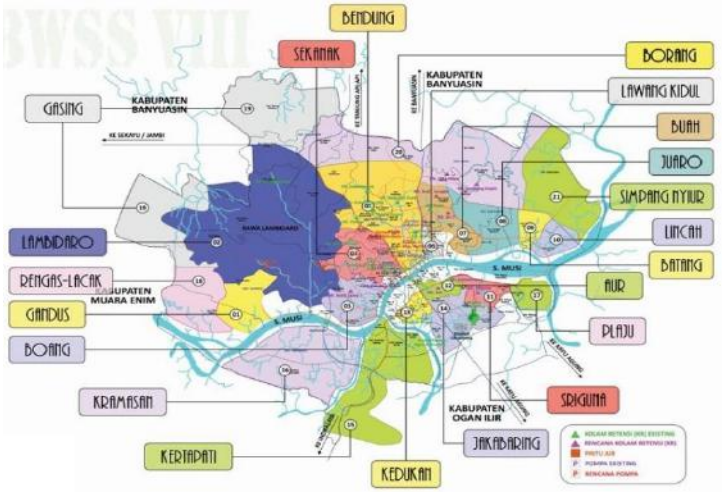

Figure 1. Palembang with 21 river basins (BBWS VIII, 2018)

This paper - discusses - the urban flood control in Palembang City in general and - focuses on the Lambidaro – Sekanak Basin. Lambidaro basin will influence the performance of Gandus basin at the downstream. Flood control in the Bendung Basin is discussed briefly under the proposed retention basins and under construction pumping station at the mouth of Bendung River.

2. PROBLEM STATEMENT

Palembang City is located about 100 km from the estuary of Musi River, and gets influenced by the vertical tidal movement. In the wet season, the highest water level is 3.7 above MSL with average high tide of 2.0 m above MSL and the lowest water level is 1.8 m above MSL. Meanwhile, in the dry season, the highest water level is 1.2 m above MSL with the average water level of +0.00 and the lowest water level is 1.2 m below MSL. Palembang City has low and flat topography and the elevation of the area is between 1.6 mm above MSL and 36 m above MSL, with the average level between 3.0 m above MSL and 4.0 m above MSL. The condition indicates that the areas below 3.7 m above MSL are the areas that are prone to - flood due to the high tide of Musi River, especially in the wet season in combination with high rainfall intensity.

Besides, Palembang City also has several man-made retention basins which its function is to store the runoff water temporarily before they can be discharged into the mainriver or drainage system. Both of them may have a significant contribution in controlling the flood and inundation in Palembang.

Besides the topographical conditions of Palembang City, flood and inundation were caused by several problems:

(a). Insufficient drainage capacity;
(b). Lack of operation and maintenance of the urban drainage system; and
(c). Lack of solid waste management.

The map of Palembang City with three different swamps is shown in Figure 2. One of them is conservation swamp which can be used for flood control system in Lambidaro -including Gandus- Basin.

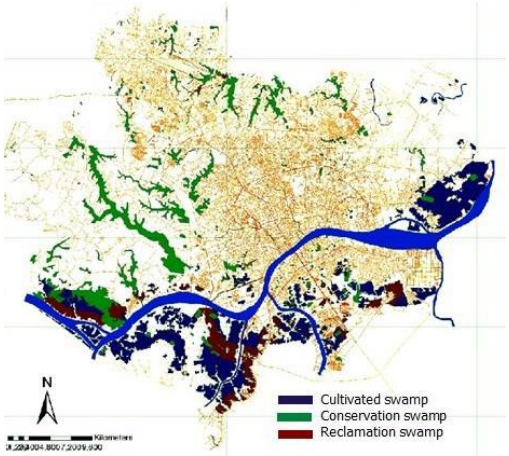

Figure 2. Map of Palembang City with three different swamps

Due to the heavy rainfall during the rainy season, some parts of the Palembang City are inundated. This is showed in Figure 3 where road is flooded by water and causes heavy traffic.

Figure 3. Urban flood in Palembang City (2018)

With regard to flood problems in Palembang City, there are several factors that lead to the situation:

3. INFRASTRUCTURE

The incapability of existing infrastructures in Palembang to handle the following conditions:

(a). sedimentation problem, because of garbage, and solid waste;
(b). insufficient drainage capacity of the infrastructure;

(c). sealed cover for most of the urban drainage systems in many places, causing limitation during the execution of maintenance (cleaning and inspection of the drainage system);
(d). area and capacity of the urban drainage and retention basins (included swampy areas).

3.1 Land Use Change

The change of the lowlands from retention basins into other uses (housing and other paved uses) has reduced the area for temporary water storage during rainy season. Moreover, the change of the land use from the green area to paved area which can reduce the infiltration capacity of the land system.

3.2 Social Culture Conditions

The awareness of the society and other stakeholders - the importance of the urban drainage system has to be improved considerably. Most of the dwellers in Palembang should be educated regarding the function of the urban drainage systems in their city and how to deal with urban solid waste. They should participate in the operation and the maintenance of the urban drainage system in Palembang City. Solid waste management should get more attention from all - related stakeholders. See Figure 4.

Figure 4. Importance of solid waste management

4. METHODOLOGY

The methodology composes of data collection and analysis (rainfall, topography, urban drainage infrastructure, tides and upstream run off from the related basins), hydrodynamic and GIS modelling and the development of the possible option for flood control in Palembang City.

A hydrodynamic model was developed for Lambidaro-Sekanak River system and as the rainfall boundary conditions are the design rainfall with 25 years return period (54 mm) with the duration of 3 hours. The downstream boundary condition at the mouth of Lambidaro River was set as the high tides at the Musi River and high tide of 1.85 m above MSL.

New urban infrastructure related to urban drainage system, urban agriculture and swamp temporary retention

To eliminate and avoid flood and other environmental problems, Palembang has set up the regulations (City Regulation number 11 year 2012) to control the use and development of swamplands (BAPPEDA, 2005 and BAPPEDA, 2006). There are three categories of swamplands in Palembang, which are conservation swamplands of 2,106 ha, cultivated swamplands of 2,811 ha and reclaimed swamplands (mainly for settlement) of 918 ha. The conservation swamplands are strictly not allowed to convert into other land use. The distribution of conservation swamps is shown in Figure 2.

In this research, an environmental approach is discussed in which the selection of swamplands may be chosen to be used as temporary storage areas for runoff water during rainy season. This could also be used for urban agricultural activities in Palembang City, but no further development of those swampy areas. Urban agriculture means agricultural activities in which plantation of vegetables that can be cultivated along the year and is shown in Figure 5. For this purpose, inlet/outlet of the swamp areas has to be designed to accommodate these functions properly.

Figure 5. Urban agriculture development

For this option, two conservation swamps along the Lambidaro basin are considered as shown in Figure 4. With this 30 ha conservation swamps in combination with a pumping station which will transfer runoff water to Sekanak, the inundation in areas along the Lambidaro and Sekanak River Basin can be solved.

The results of hydrodynamic model simulation show that by utilising the conservation swamps of 30 ha, the water level can be lowered by 1.20 m as presented in Figure 6.

Increasing to 60 ha of the storage area will lower it by 1.40 m. It means that in the case of 30 ha of conservation swamp, it is sufficient to control the flood where with 1 m storage about 300,000 m^3 water will be stored. In the case where water would be used for urban agriculture, the area of the urban agriculture can be designed. It is estimated about 50 to 60 ha of urban agriculture can benefit from this temporary storage area (with the duration of about two months). This shows that the conservation swamp is able to serve both purposes: as temporary water storage and flood control water retaining area. Especially for Gandus Basin, we will keep it free from the flood control system for Palembang City mainly because the plan is to develop Gandus area as agropolitan (Marlina Sylvia, 2009). It is assumed that in the future the Gandus Basin will also be integrated with other river basins in Palembang area.

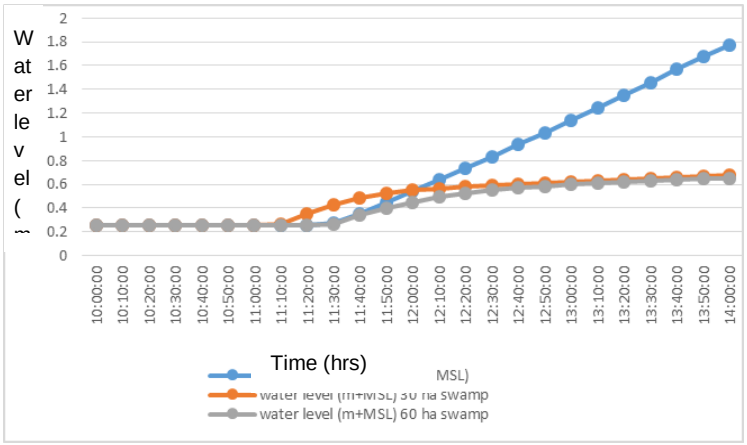

Figure 6. Water level without temporary storage and with 30 ha and 60 ha swamp (conservation swamp)

Another measure in this Lambidaro-Sekanak System is by carrying out interbasin transfer from Lambidaro to Sekanak River. By transferring run off water to Sekanak River, it is expected that the surface run off is able to flush away the polluted water in Sekanak River and eventually improving the water quality of Sekanak River. This option is in line with the Palembang Municipality's strategy on the restoration of Sekanak River. The river restoration has been started and can be seen in the river restoration of Sekanak River as shown in Figure 7.

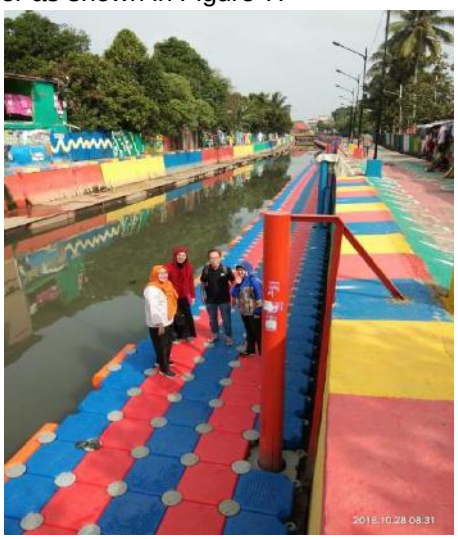

Figure 7. Sekanak river restoration

More systematic and detail programme for the river restoration need to be planned including bio-remediation of the river water quality.

4.1 Flood Control System In Bendung Basin

For Bendung Basin, flood control will be done by normalisation and dikes contruction along the river system. For the flood control system in Bendung Basin, an operation rule of the pumping station has to be derived. The pump operational condition shall be well formulated. Along the Bendung Basin there exists four retention basins (TalangAman, SedudukPutih, IBA and SimpangPolda). With these measures, the

inundated area can be reduced from 285 ha to 46 ha only (reduced by 85%) and it is expected that in the mid 2019, the pumping station at the Bendung River will be in operation.

The operation, management and maintenance of the pumping station at the Bendung River mouth is under the River Basin Authority VIII (BBWS VIII) in Palembang. But, in general the operation and maintenance of water resources and urban drainage system in Palembang City is under Spatial Planning and Water Resources Services of Palembang Municipality. It is clear that a proper coordination between the River Basin Authority (BBWWS VIII) and Spatial Planning and Water Resources Services needs to be developed.

Figure 8 presents the construction of the Pumping station at the Bendung River mouth which consists of retention basin, pump station, gravity outlet and improvement of dikes and embankments.

Figure 8. Pumping station at Bendung River mouth (Bisnis.com, 2018)

5. OPTIONS TO BE CONSIDERED

To solve the urban flood problems in Palembang City there are some options which can be considered:

(a). Increase the urban drainage capacity including the outlet capacity (normalisation of Lambidaro - Sekanak River including to construct dikes with 1.5 m height as shown in Figure 9;

Figure 9. Normalization of urban drainage system in Palembang City

(b). To install gates and pumping station (Q= 4 m3/s) at the connected point between Lambidaro and Sekanak River in combination with the improvement of operation, monitoring, evaluation and maintenance programme. By installing a pumping station, the water level will be reduced about 10 cm in this part of Lambidaro River. The water level along this part of Sekanak River will be at 1.6 m above MSL where the ground surface elevation is about 2.36 m above MSL;

(c). To use the swampy areas in the extreme conditions as temporary storage areas of the run-off and use it for the urban agriculture development especially in dry season or release the run-off as soon as the water level in the main river is sufficiently low. This temporary storage has to be completed with inlet/outlet structure which will control the flow to and from the storage;

(d). As a temporary storage and conservation swamps, it means that during 'normal' conditions, these swamps have to function as natural swamps without any development plans.

6. DISCUSSION

In fact, most of the inundation sites are located along Bendung and Sekanak catchment areas. But, for Bendung Basin, flood control is managed by the River Basin Authority in Palembang and at the mouth of Bendung River, a pumping station is already installed.

In this discussion we will focus on Lambidaro – Sekanak Basin. It means that to solve the inundation problems, the urban drainage system shall be checked thoroughly on these two basins by integrating the usage of Lambidaro Basin where it is connected already with Sekanak Basin.

The swamp areas along Lambidaro could be used to store the run off during extreme rains and the stored run off water can also be used for flushing of Sekanak River. The dynamic storage of the swamp areas has to be maintained in order to accommodate the run off of the next rainfall. The total potential conservation swamps in the upper part of Lambidaro River is about 220 ha to be utilized as the temporary storage areas during rainy season. In fact, from the result of the model simulation, the area of conservation swamp for controlling the flood is only about 30 ha. With a 30 ha of temporary storage, water level in the Lambidaro River will be reduced by 1.20 m. It means that the effect of the temporary storage is remarkable effective and we may consider this option seriously and with the principle that they will function as temporary storage only and will remain as conservation swamps. In this case, the outlet should be only one direction flow to the temporary storage area. Run-off water will be kept in the storage area and will be released after the period of the heavy rainfall. In the future, if necessary, we could consider to keep the runoff water and utilise it in the dry season for agriculture or flushing purposes. More detail researches need to be done especially related to the environmental impact of this option and how to minimize the impacts.

By considering the socio-cultural background of the stakeholders, it is clear that training and technical guidance have to be organized on a regular basis and as a continuous process. The purpose is to guide and train all the related societies and stakeholders how to manage and maintain the urban drainage systems included to manage solid waste in their areas.

7. CONCLUSION

Some conclusions can be drawn based on the data analysis and the evaluation of the modelling:

(a). To solve the inundation problem in Palembang City, a combined measure, integrating structural and non-structural should be considered. Next to that a proper coordination has to be done between The River Basin Authority (BBWS VIII) who operate and manage the pumping station at Bendung River mouth and Spatial Planning and Water Resources Services of Palembang Municipality who operate and maintain all the urban drainage and water resources system in Palembang City;

(b). Structural measures compose of some hydraulic measures (pumping stations, used of un-reclaimed swamps as temporary storage areas and improved urban drainage capacity);

(c). Inter basin transfer from Lambidaro to Sekanak River should be considered which may give also another benefit related to the Sekanak River restoration plan (flushing);

(d). Un-reclaimed swamps along Lambidaro, Bendung and Sekanak River must be conserved and will only be used for flood control during the extreme rainy season;

(e). Improved operation and maintenance of urban drainage system by executing the regular maintenance program before the rainy season is coming;

(f). Improved non-structural measures by training, guidance and workshop on stakeholder involvement of flood management;

(g). Training, guidance, technical guidance for different levels, societies and stakeholders of operation and maintenance of urban drainage system should be organized on the regular basis till all the related stakeholders may accept, understand and are willing to do it.

8. ACKNOWLEDGEMENT

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9. REFERENCES

Haryo Istianto, F.X. Suryadi and Sumi AmarienaHamim. Potentials and constraints of urban polder development in Jakarta, Indonesia. Case study: RawaBadak Polder. IAHR, 2017. Kuala Lumpur, Malaysia

KittiwetKuntiyawichai, Quan van Dau, Winai Sri Amporn, F.X. Suryadi. An assessment of flood hazard and risk zoning in the Lower Nam Phong River Basin, Thailand. International Journal of Technology. 2016

Marlina Sylvia R.A.Options for Water Management and Flood Protection of AgropolitanGandus for Agricultural Development, Palembang, Indonesia. MSc thesis IHE Delft, UNSRI Palembang. 2009

Mohammad Farid, AyuMarlina, Muhammad SyahrilBadriKusuma. Flood hazard mapping of Palembang City by using 2D model. AIP Conference Proceedings 1903(1):100009. 2017, Palembang, Indonesia.

Sumi Amariena Hamim, FachrurrozieSjarkowi and F.X. Suryadi. Effects of Uncontrolled landuse change to the inundation pattern and its possible measures.Case study: Lambidaro

lowland subsystem in Palembang, 35th IAHR World Congress, September 2013, Chengdu, China

Suryadi, F.X., Eddy Santana Putra, Kira Tarigan, AkhmadBastari and Marlina Sylvia. Strategy of drainage and flood control in Palembang City. Proc. 6th Asian Regional Conference of International Commission on Irrigation and Drainage, October 10 - 16, 2010.Yogyakarta, Indonesia