Identification Study on Water Management System ini Liang Polder, Banjar Regency, South Kalimantan Province

by Ahmad Saiful Haqqi

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on

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International Symposium on Lowland Technology

ISLT 2014

Preface

The International Symposium on Lowland Technology has been held biennially from 1998 and we reached the 9th meeting at ISLT2014. During the last 18 years, most were held in Saga, Japan. However for this decade it was held in Bangkok, Busan and Bali in 2004, 2008 and 2012, respectively.

When this event was held in attractive cities outside Japan, many participants in the symposium enjoy the atmosphere and ambience of these cities as well as deepen their knowledge on issues involving Lowland. Saga is also still one of typical lowlands in the world, however, touching different features in other lowland areas are also very interesting and informative. Especially, comparing to previous symposium in Bali 2012, that collected 160 papers from 17 countries, the ILMR local organizing committee made great effort for the preparation of the symposium so that we will obtain the result as good as Bali. Finally and fortunately, a total of 130 papers from 11 countries are published in this proceedings.

On average, around 120 papers have been constantly submitted to every past ISLT. It means that many researchers and engineers are interested in lowlands. Furthermore, the term of "lowland" is becoming popular and increasingly has more significant meaning in the era of climate change. Following the same direction, the official journal of IALT, Lowland Technology International, also continues to develop with expanding fields of (i) Geotechnical/Geoenvironmental Engineering, (ii) Water/Environmental Engineering, (iii) City/Urban Planning and Management, (iv) Coastal Science and Engineering and (v) Remedial Measures for Lowland Management.

Those academic publications had played important role in the development of academic disciplines concerning lowlands and thus are essential activities. I hope ISLT2014 in Saga will successfully give fruitful outcome and contribute knowledge to all the participants.

荒木宏之

Prof. Hiroyuki Araki
Chairman of Organizing Committee
ISLT 2014 Saga

President's Address

It gives me immense pleasure to welcome all to the 9th International Symposium on Lowland Technology at Saga University, Saga. This symposium follows after the very successful ones at Saga, Busan, Bangkok and Bali. All of us have very fond memories of the very fruitful 8th Symposium in the picturesque resort in Bali. The current one also promises to be equally valuable if not more with more than hundred papers accepted and included for presentation.

ISLT showcases the progress and developments in the field of Lowland and Marine Research with the theme **'Problems and Remedial Measures of Lowlands'** under various topics such as (i) Geotechnical/Geoenvironmental Engineering, (ii) Water/Environmental Engineering, (iii) City/Urban Planning and Management, (iv) Coastal Science and Engineering and (v) Remedial Measures for Lowland Management. More than hundred papers have been received, accepted for publication and presentation. ISLTians can thus look forward to an update on various topics during the Symposium Sept. 29th to Oct. 1st, 2014 in the home grounds of Saga University, the fount for the genesis, nurturing, developing and spreading the knowledge in this area.

It should be noted that nearly twenty five years after the topic is identified for study, the International Society of Soil Mechanics and Geotechnical Engineering is now proposing to have a new Technical Committee on 'Land Reclamation'. I have always felt that just as humans give birth to life and nurture the baby/infant to life, we at IALT, ILMR and erstwhile ILT have been working diligently to create land and making it functional with all attendant concerns in terms of improving the ground, water, environmental, city/urban planning, coastal and sustainability issues.

While remembering the creators and sustainers of IALT, Prof. Miura, Prof. Poorooshasb, Prof. Hayashi, Prof. Kim, etc. we all should compliment the present team of Prof. Araki, Prof. Bergado, Prof. Yamanishi, Prof. Hino, Dr. Azizul, Dr. Suman, Dr. Lam and several others for their untiring efforts to make this Symposium a success. Ms Mariko Yahiro, the ubiquitous worker behind the scenes, is a great asset to all our efforts.

Wishing the Symposium a great success with all your presence and participation and looking forward to meet you,

M R Madhav
President, IALT

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9th International Symposium on Lowland Technology
September 29-October 1, 2014 in Saga, Japan

IDENTIFICATION STUDY ON WATER MANAGEMENT SYSTEM IN LIANG POLDER, BANJAR REGENCY, SOUTH KALIMANTAN PROVINCE

N. Fithria[1], N. Helda[2] and N. Amal[3]

ABSTRACT: Banjar Regency had encountered flooding problem for the last several years. Polder Liang became one of the solutions in Banjar Regency which had been built since the Dutch Colonization. However, in its current condition, the area that supposed to be developed as retention ponds cannot be function optimally; it was caused by water level control and waterworks system. The methods of this research include: field surveys, problem identification, problem definition, literature review, data collection, and analysis of hydrological data. Survey and investigation include tracking and waypoint GPS, then represent to ArcGIS software. Furthermore, hydraulics analysis was used to calculate flow design and Liang Polder's channels. The result of the study is to develop a database of Liang Polder. From the research, it is known that Liang Polder covers large area about 1.412,8 Hectares is potentially area but it is unable to optimally function because the number of water gates (5 main sluice gates and 20 small sluice gates). Nevertheless, one important role for input and output water in the polder is the work of water gates. Consequently, it needs to optimize the operational and maintenance sector, especially for retention areas when rainy season comes.

Keywords: Polder, water management system, water gates, retention area

INTRODUCTION

As one of lowland area in Indonesia, South Kalimantan has a number of polders which were built in the colonial era. Nowadays, one of the polders that is under the authority of the Local Government and has an area of 1000 ha - 3000 ha is Liang Polder. It is located in Martapura, Banjar Regency, South Kalimantan Province, Indonesia as can be seen in Fig. 1.

At one hand, large areas of lowlands in South Kalimantan are not yet well developed where on the other hand their potential might lead to food production and other utilization. Liang Polder is an existing irrigation area which is being developed on an ongoing project basis. Currently, South Kalimantan Provincial Government delegates Department of Public Works South Kalimantan province to empower and manage the polder. Liang Polder Rehabilitation Area of 700 Hectares is the key target in 2013.

Rehabilitation in Liang Polder is due to the current flooding problems that Banjar District is still facing off. Based on the data from the Regional Disaster Management Agency it was recorded that the frequency of flood occured 9 times in the year 2012, thus caused a great loss in 9 districts in Banjar (Fakhruzzein 2012).

Fig. 1 Location map of Liang Polder

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Polder Liang has an area of 1412.8 Hectares and surrounded by a paved road embankment and has 25 water gates. There are many rivers around the polder namely: Arpat, Antasan, Bincau, Antasan Ambawang Besar, Baku River respectively (Department of Public Works, South Kalimantan 2011).

Swamp Aspects

Marsh can be distinguished on the tidal marsh and swamp non tides. Tidal marsh (Noor 2004) is defined as the swampy areas which are influenced directly or indirectly by the ebb and flow swing of sea water and/or surrounding rivers. While the swampy marsh (Noor 2007) is the area of land that has a pool of nearly all year round for at least three months with a pool of at least 50 cm high. Swampy marsh is used or cultivated for agricultural development, including fisheries and livestocks, therefore it is also called swampy wetlands. Because of its position that is far away from the estuary entrance/large rivers, lowland swamps are often referred to as inland marsh.

Based on the height and duration of inundation (Noor 2007), swampy wetlands can be divided into three types, namely (1) shallow valley, (2) mid valley, and (3) deep or very deep valley.

Swampy bogs and lakes have very important environmental functions with respect to flooding, especially during high rainfall intensity. The surface area of swampy bogs or lakes act as water reservoir which store large amount of water while it does not yet flow into rivers permanently. Besides, swampy surroundings and the lake also function as a catchment area.

Polder System

Polder is defined as an area or a land reclamation with the initial condition has a high water table, which is isolated hydrologically from the surrounding area and the water level (surface water and ground water) can be influenced according to the conditions which were left on their original land elevation or slightly elevated.

Isolation can be done to prevent water that comes from outside the polder. The water in the polder is controlled by drainage system or sometimes in combination with irrigation system.

The components that must exist on the polder system include:

1. Embankment and Sea defense
2. Field drainage system
3. Conveyance system
4. Outfall system
5. Recipient waters

Polder system needs proper management. Polder management, operation and maintenance are intended to prevent a decline in the function of all the elements that exist in the polder system, covering dikes, drainage network, tendons pool, pump stations, and receiving waters

OBJECTIVES

The study was conducted to:

a. To identify the existing condition of the water system in the Polder Liang.

b. To analyze the function of Polder Liang Polder as agricultural areas during the dry season and as a retention area in the wet season.

c. To determine the appropriate method for the operational and maintenance of Liang Polder.

METHODOLOGY

The study consists of two sets of works as follows:

1) Identification of Liang Polder
2) Liang Polder Data Processing

The methods of this research include: field surveys, problem identification, problem definition, literature review, data collection, and analysis of hydrological data. Survey and investigation include tracking and waypoint GPS, then represent to ArcGIS software.

The flowcharts of Identification Study and Data Processing of Liang Polder are represented in Fig. 2 and Fig. 3.

RESULTS AND DISCUSSIONS

Field Surveys

Field surveys were conducted to review the study site directly in order to obtain documentation of the conditions in the study area associated with:

1. Identification of the water system at Liang Polder.
2. Irrigation facilities that exist in the Polder Liang.
3. Area utilization/optimization and maintenance of polders by residents.
4. Environmental conditions and settlements around the Polder.

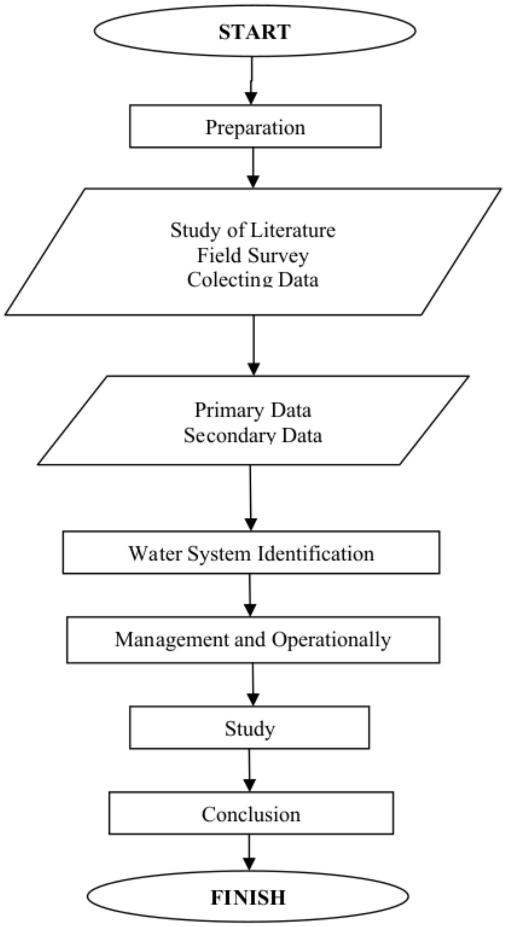


Fig. 2 Flow chart of identification study of Liang Polder

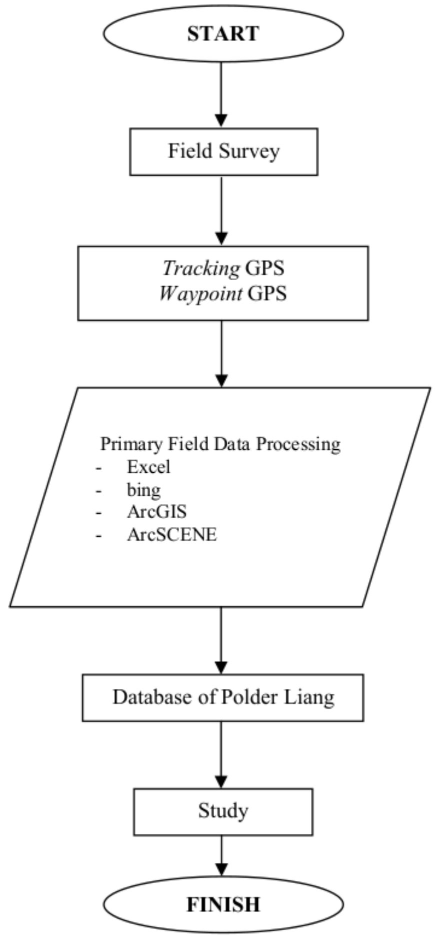


Fig. 3 Flow chart of Liang Polder Data processing

Data Inventory

From the field surveys, it is known that Liang Polder is located on geographical coordinates of 3°24'06.98'' South Latitude and 114°53'32.04'' East Longitude with an area of 1412.8 Hectares. General and Technical Data of Liang Polder is shown in Table 1. It has 5 main gates and 20 small gates in good condition (except main gate 3, 4 and 5) with the dikes length of 17.5 kilometers. Liang Polder is a polder which can be used for agriculture land in dry season and as a retention pond in rainy season.

Water System Identification

Based on the observations, it can be identified that Liang Polder is a semi- technical Polder. It is still manually operated, also the irrigation and drainage channels are not completely separated.

Liang Polder area has six rivers that flow inside and outside the polder. The first river is a Liang River, then Arpat River, Besar River, Antasan Ambawang River, Baku River and Antasan River with a length of about 5404 m, 1354 m, 697 m, 1936 m, 309 m and 245 m respectively. The detailed flow and topography of Liang Polder are shown in Figs. 4 and 5.

It is also known that from 25 water gates, 40% are in good condition for 8 small gates and 2 main gates, 40% are in not good condition for 10 small gates and the last 20% are in the improvement process for 2 small gates and 3 main gates. The detailed condition of all water gates is explained in Table 2.

In addition to dikes, polder water system is also supported by the water gate surrounding the polder. When the water level rose during heavy rainfall exceeds

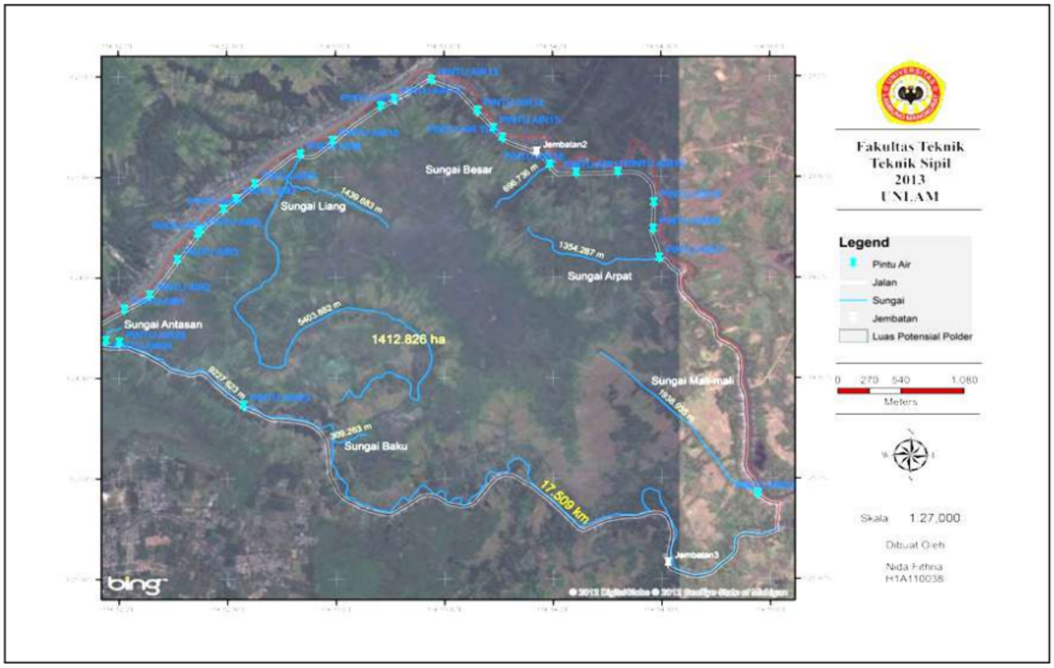


Fig. 4 Details of river flow and water gates

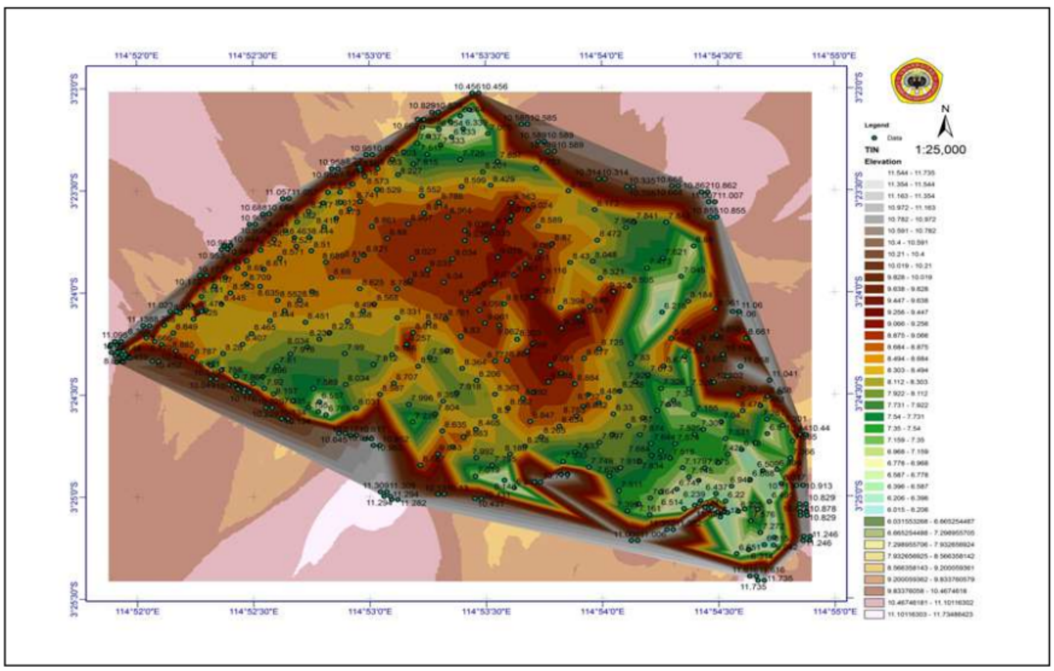
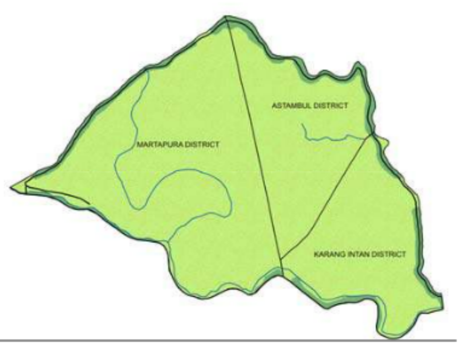


Fig. 5 Topography map of Liang Polder

Table 1 General and technical data of Liang Polder

General and Technical Data Polder Liang		
Data Infrastructures Polder Liang		
District :		1. Martapura 2. Karang Intan 3. Astambul
Name :		Polder Liang
No	**Item**	**Description**
1.	Polder Area	1412.8 ha
2.	Coordinates	3°24'06.98'' S and 114°53'32.04'' E
3.	Number of Villages	12 villages
4.	Existing building types	Main Sluice Gate : 5 gates Small Sluice Gate : 20 gates Dikes Lenght of Liang Polder : 17.5 kilometers.
5.	Rivers around the Polder	1. Sungai Bincau 2. Sungai Martapura 3. Sungai Riam Kanan
6.	Utilization of Polder	1. As agricultural land in the dry season 2. As a retention area in the rainy season
7.	Rivers in Polder Liang	1. River Liang 2. River Arpat 3. River Antasan 4. River Antasan Ambawang 5. River Besar 6. River Baku
8	Liang Polder Delineation	Digitation Map of Liang Polder (Source : Bakosurtanal 1999)



the capacity, the polder system will work with the operation of water gate manually to open the gate so that water can drain out the water until the water in the polder areas in the polder in normal circumstances.

All the main gates at the Polder during the rainy season serves as an outlet to the river channel around

Table 1 Items of three variables

No	Gate	Count	Width (m)	Condition
1	Main gate 1	1	3	Good
2	Main gate 2	1	3	Good
3	Main gate 3	1	3	Repairement Process
4	Main gate 4	1	3	Repairement Process
5	Main gate 5	1	3	Repairement Process
6	Small gate	20		Good and Not Good

Polder Liang, namely Martapura River, Cascade River Right, and Bincau River. Therefore, when there is a local rain for a few days, Liang Polder channels cannot accommodate the flow of water coming in, the area will be flooded high enough. Topography is relatively flat and evenly distributed rainfall which felt in the upstream areas causing the rise of water level to equal of the elevation of Liang Polder dikes. Rising river water resulting in water elevation from the river into the polder area of agricultural land causes flooded for a considerable time.

Figure 6 shows the rivers around Liang Polder. From the figure, it can be seen that Liang Polder serves as outlet.

Complementary Buildings

1) Dikes

Liang Polder is surrounded by long dikes of about 17.5 kilometers. The main function of this dike is to protect the polder areas and isolate the effect of the water from outside Liang Polder. The conditions of the dikes are good because they are paved road as shown in the next Fig. 7.

Fig. 6 Liang Polder serves as outlet

Fig. 7 Dikes as paved road in Liang Polder

2) Irrigation

Liang Polder Irrigation in the area is a channel with a diameter of ± 1 meter which serves to irrigate the rice fields during the growing season until harvest. Irrigation is derived from irrigation canals of Riam Kanan Reservoir that can be operated with the gate control as shown in Fig. 8.

3) Drainage

Here is a drainage culvert with dimensions of 50 cm which serves as a means of disposal without control open and close if there is excess water from the area outside the Liang Polder. Untreated drainage conditions shown in Fig. 9.

Fig. 8 Irrigation channel in Polder Liang

Fig. 9 The channels are not maintained

Fig. 10 Cages of fish Farming under the bridge

4) Bridges

Bridges are structures which are built to connect the two roads that cut off because of the river. There are 3 bridges in Polder Liang area. In Fig. 10, many cages are used for fish farming in the river.

Hydrological Analysis

When there is no correlation between adjacent observations, the output of a hydrologic system is treated as stochastic, space-independent and time-independent. This type of treatment is appropriate for observations of extreme hydrologic events, such as floods or droughts and for hydrologic data averaged over long time intervals, such as annual precipitation (Chow et al. 1988).

Rainfall Characteristics

Rainfall characteristics in an area can be only well defined if long term rainfall data is available. It means that the annual maxima data is suitable enough for extreme value distribution analysis (Gautama 1997). In most cases, it is difficult to meet this condition.

Rainfall is considered as a random event and it varies geographically, temporally and seasonally. Methods of statistical analysis have been developed to identify rainfall characteristics (Gautama 1997). Liang Polder should be properly designed to handle extreme rainfall events during its design life.

Rainfall Data Series

There are two types of data series for extreme events. A partial duration series is a series of data which are selected so that their magnitude is greater than predefined base value. An annual series data takes one highest or lowest data from each of a record (Chow et al. 1983).

According to Triatmodjo (2009), partial duration series (also called Peak Over Threshold, POT) is used if the available data is less than 10 consecutive years. Therefore, in one year there are more than one data used in the analysis. In each year, second to fifth highest data can be chosen for the analysis. For annual maximum series, the available data is more than 10 consecutive years. By choosing one maximum data for each year, the second highest data which probably higher than maximum data from other year will not be considered.

In this study, the available rainfall data from Pengaron Station, Station Martapura, Aranio Station, Station Simpang Empat, and Matraman Station were just erected from 2007 to 2011 (uncomplete data). Consequently, only small number of annual maxima data is available. In this case, the only analysis which can be done is using partial duration data series. Then, the calculation of the mean areal rainfall are presented in Table 3.

For Maximum Rainfall Analysis, statistical parameters required for the calculation were the middle value, standard deviation and coefficient of skewness. Gumbel and Log Pearson Type III distribution were used to describe the probability of annual maximum flood peaks, since these two methods are recommended (de Laat and Savenije 2002). The Log-Pearson Type III was developed as a method of fitting a curve to data. Its use is justified by the fact that it has been found to yield good results in many application, particularly for flood peak data (Chow et al. 1983).

Testing the probability distribution is intended to determine whether the selected probability distribution equation can represent the statistical distribution of the data sample analyzed. There are two methods of testing the probability distribution, the method of Chi-Square (Chow et al. 1983) and Kolmogorov-Smirnov method.

The results of Rainfall Distribution Analysis and the probability distribution test can be seen in Table 4, Table 5 and Table 6 respectively.

Based on Table 4, 5 and 6 the best distribution is Log Person type III distribution. Therefore, in the calculation of rainfall frequency analysis, Log Pearson type III probability distribution was used.

Table 3 The calculation of mean areal rainfall using partial duration data series

No	Data on average daily rain (mm)	No	Data on average daily rain (mm)
1	71.50	11	42.00
2	71.00	12	41.83
3	63.00	13	41.00
4	60.33	14	39.67
5	58.95	15	39.43
6	58.22	16	37.50
7	56.83	17	37.00
8	50.75	18	35.63
9	48.93	19	35.50
10	48.83	20	35.3

Table 4 The results of rainfall distribution analysis

Return Periods T (years)	Gumbel Distribution (mm)	Log Pearson type III Distribution (mm)
2	46.9	46.7
5	59.7	57.6
10	68.1	64.8
20	76.3	70.8
25	78.8	73.9
50	86.8	80.8
100	94.6	87.8

Table 5 The results of the Chi-square test for various methods of probability distributions

Probability Distribution	X^2	$X^2 cr$	Subscribe
Gumbel	29.8	7.8	Not Allowed
Log Pearson Type III	2.8	7.8	Allowed

Table 6 The Results of the Smirnov-Kolmogorov test for various methods of probability distributions

Probability Distribution	ΔP	ΔP_{kritis} 0.05	Subscribe
Gumbel	1.67	0.29	Not Allowed
Log Pearson Type III	0.13	0.29	Allowed

Rainfall Intensity

Available rainfall data were daily rainfall data. Which can be determined by Mononobe Formula (Suripin 2004). The correlation between intensity of short time rainfall duration and 24-hour rainfall follows the Mononobe's equation (Sosrodarsono and Takeda 1983).

$$I_t = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^m \tag{1}$$

Where I_t is rainfall intensity in mm/hour for duration t, R_{24} is 24-hour rainfall and m is 2/3.

Table 7 presents the calculation of the Design Rainfall Intensity for each river in the Liang Polder with Mononobe's approximation to determine rainfall intensities.

Intensity Duration Frequency (IDF) Curve of daily rainfall data at Liang Polder area for 10 years return periods can be seen in Fig. 11 as shown below:

Table 7 The rainfall intensity in Liang Polder

No	Name of river	X_t (mm)	t_c (hour)	I (mm/hour)
1	River Liang	64.8	8.7	7.4
2	River Besar	64.8	0.6	30.8
3	River Arpat	64.8	1.4	53.5
4	River Antasan	64.8	0.2	68.9
5	River Antasan-Ambawang	64.8	2.0	32.0
6	River Baku	64.8	0.2	57.5

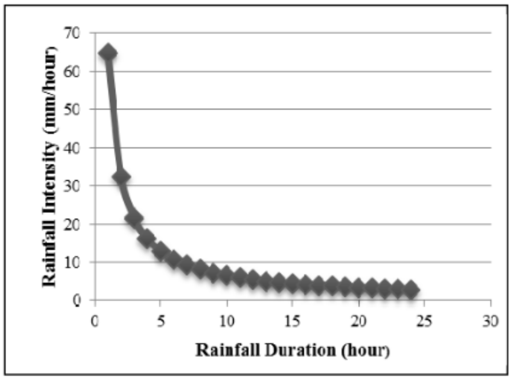


Fig. 11 IDF Curve for 10-years return periods

Design Discharge Analysis

Rational Method was used to calculate the discharge in this study. Rational Method can be used to calculate the peak discharge of the river with limited drainage.

In Liang Polder area that has relatively flat topography, the runoff coefficient of 0.4 was taken. The River discharge for Liang Polder was calculated using Manning Formula:

$$Q = \frac{1}{n} R^{2/3} S^{1/2} A \quad (2)$$

where Q is discharge in m^3/s with hydraulic radius R, S is slope and A is area in m^2.

Table 8 shows the comparison of Design Discharge (Q_D) and River Discharge (Q_S). River Discharge (Q_S) was measured in the field study.

From the comparison, it can be concluded that the cross-sections of Rivers in Liang Polder were unable to accommodate local rainfall occurred. Then the next step is to calculate the economical cross-section channels so that they can accommodate the design discharge which is presented in Table 9.

Table 8 The comparison of design discharge (Q_D) and river discharge (Q_S)

River	Q_D (m^3/s)	Q_S (m^3/s)	Conclusion
River Liang	6.6	0.8	Not being able to accommodate
River Baku	16.0	13.2	Not being able to accommodate
River Besar	8.7	6.2	Not being able to accommodate
River Arpat	29.3	1.4	Not being able to accommodate
River Ambawang	18.5	0.6	Not being able to accommodate
River Antasan	28.5	13.0	Not being able to accommodate

Table 9 Calculation of economical cross-section with manning equation

River	L (m)	Q_T (m^3/s)	S	h (m)	B (m)
River Liang	6843.6	6.6	0.000146	2.8	3.2
River Baku	309.3	16.0	0.003233	2.2	2.5
River Besar	696.7	8.7	0.001435	2.0	2.3
River Arpat	1354.3	29.3	0.000738	3.6	4.1
River Ambawang	1936.9	18.5	0.000516	3.2	3.7
River Antasan	244.2	28.5	0.004095	2.6	3.0

As conclusion, to be able to accommodate local rainfall which resulted to design discharge of Liang Polder, the channels must have a cross-sectional size as seen in Table 9.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the survey results and the identification also the analysis which have been conducted in Liang Polder, it can be concluded as follows:

1. Polder Liang is a semi-technical polder because water is still operated manually through the door that is not equipped with a flow meter and the carrier channel and the drainage channels are not completely separated. All primary floodgates on Liang Polder serve as the outlet from the Polder. In addition, not all of surrounding dikes elevation in Liang Polder are higher than in the

polder area , but there is still a levee on the river side elevation namely Bincau which is parallel with elevation in the Liang Polder thus affected the flow of the channel.

2. Given the original polder land in a swampy bog, which is not equipped with a drainage system to drain the stagnant water in the polder, land use for agriculture can only be done during the dry season, when water in the polder has been relatively shallow. While the analysis is based on the ability of flood retention in Liang Polder, It is not able to accommodate the discharge of rainfall due to local rainfall. This condition is in accordance with the existing conditions in the field that is still going on until the flood water level due to overflow into the embankment of the incoming flow of natural channel around the Polder.

3. Currently, Liang Polder cannot serve its function due to lack of optimization and maintenance actions are performed , considering the condition of the channel in the Liang Polder and condition of the building is 40 % are in damage condition . So the optimization actions that can be done is to repair and dredge the channel to be able to drain naturally from the water entry in the polder. While the preventive measures that can be done for maintenance Liang Polder is a routine maintenance on all buildings in the area of Liang Polder.

Recommendations

1. Polder Liang under the supervision of the Department of Public Works should have complete data on the existing condition of the Polder that can be fully utilized.

2. Based on the results of the inventory and identification Polder Liang, hence the need for further research in Polder Liang in order can function more optimally.

3. Appointment of delegates of the local community by the relevant agencies to be given a briefing in maintaining and controlling the floodgates and encourage local communities to raise awareness to keep the channel in the Polder Liang

4. Need to increase the activity and function of the area under Polder farmer groups in order to increase agricultural output to improve people's prosperity in neighboring area of the Polder.

5. Land use around the dike should be controlled as tightly as possible. At least, along the banks of the river and canal embankments should be free of buildings and settlements illegal because if flood happens it will inundate the region.

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