J. Basic. Appl. Sci. Res., 6(3)1-8, 2016
© 2016, TextRoad Publication

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Modeling Scenario of Operation and Maintenance Real Demand Value on the Main Drainage Infra-structure

Hari Suprayogi[1*], M. Bisri[2]

[1]Doctoral Program on Department of Water Resources, Faculty of Engineering, University of Brawijaya, Malang, East Java of Indonesia
[2]Lecturer on Department of Water Resources, Faculty of Engineering, University of Brawijaya, Malang, East Java of Indonesia

Received: December 23, 2015
Accepted: February 6, 2016

ABSTRACT

This study intends to know an index formulation that can illustrate the performance of main drainage infra-structure in the function for flowing water from a region. The methodology consists of inventory and identifies the problems of infra-structure and inundation which is happened on main drainage, then analyzing the cost and loss, and by the end there is obtained the operation and maintenance real demand value on main drainage infra-structure. The output will show the real demand value in unit price per-ha or per-m^3 based on the result on analyzing of drainage infra-structure performance in reducing inundation on a region where there is the drainage network.
KEYWORDS: real demand value, operation and maintenance, main drainage

INTRODUCTION

Based on the President decision of Indonesia Republic No 12 (2012), the river area of Progo, Opak, and Serang consist of three catchment areas such as Progo, Opak, and Serang. The Catchment areas enter in working area of Big Institution on River Area of Serayu-Opak. Administratively, parts of number area is the river area of Progo-Opak-Serang which is included the regencies of Kulonprogo, Bantul, Sleman, Gunungkidul, Yogyakarta city, Magelang Regency and Magelang City. In addition, there are some small parts of the regencies of Purworejo and Wonosobo.

In dry season, the condition of river estuary on river area of Progo-Opak-Serang is generally happened the stoppering by sediment on river mouth surrounded the estuary and by the end the water level is increasing and the backwater as well as flooding water, so it causes the inundation on agriculture area and the area surrounded the estuary [1][2]. To solve the problem, government has carried out a handling effort by planning the development on controlling facility of water damage force as well as the suitable saving structure like bank protecting structure, dyke, crib, drainage, groundsill, jetty, groin, etc. Study and handling the flood management on the river area of Opak-Serang comprehensively in the end there is planned by BCEOM consultant on the work of South Java Control Sector Project (SUFCSP) and it has been carried out thr physical work since 2005 until 2007. The work includes the handling of river bed, river estuary, and the drainage that estuaries in the main river [3]. After a few years, the problem is really still happened along the main river and drainage. The performance of drainage network is not optimal so the problem of inundation is still happened in the region where there has been the drainage network such as Kulon Progo Regency as well as in Bantul Regency.

Flood in the beginning of rainy season is as the time that is necessary to pay attention because at this time the rainfall is not too big and the condition of river estuary is opened by sand spit. By the discharge that is relatively small so flood cannot directly towards sea and it causes inundation in right and left side of river. This stoppering also causes the drainage along the main river cannot be well functioned. This study intends to know an index formulation [4][5] that can illustrate the performance of main drainage infra-structure in the function for flowing water from a region

MATERIALS AND METHODS

Big Institution of River Area (BBWS) on Serayu-Opak is divided into two river area such as river area of Serayu Bogowonto which is all of them is administratively located in Middle Java Province and river area of Progo-Opak-Serang which is through two provinces such as Middle Java and Daerah Istimewa Yogyakarta. Figure 1 presents eorking area of River Area Big Institution on Serayu-Opak.

***Corresponding Author:** Hari Suprayogi, Doctoral Program on Department of Water Resources< Faculty of Engineering, University of Brawijaya, East Java of Indonesia. Email: Yogibsolo@gmail.com

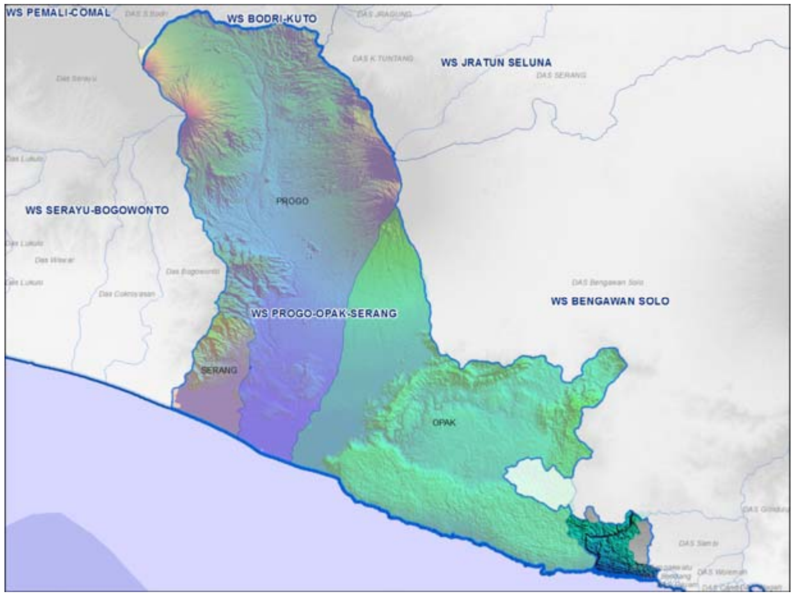


Figure 1 River area of Progo-Opak in the working area of Serayu-Opak River Area Big Institution

River area Progo-Opak-Serang includes four regencies and one city such as regencies of Sleman, Kulon Progo, Bantul, Gunung Kidul, and Yogyakarta city.

Narrowing and moving of river estuary mouth is as one of the reasons the happening of flood on the south side of Java Island. It is due to there is sediment which is parallel to the shore which is taken by sea wave towards estuary mouth. The very dangerous impact is when the beginning of rainy season that causes flood which is inundating the residence and irrigated rice area of the citizen.

Flood in the beginning of rainy season is very dangerous. At this moment, the rainfall has not been too high but the condition of river estuary is opened by sand spit, so the flood cannot directly towards sea and it causes inundation on the right and left side of river flow. Stoppering by sand spit will cause neither flooding or inundation in the beginning of rainy season nor the river estuary is moving.

Topography

Topography condition.on the river area of Opak-serang is generally consisted of mountainous areas, hills, and low land, there is in Middle Java Province as well as Daerah Istimewa Yogyakarta Province as in Figure 2 below. Based on the venography outlook, river area of Progo-Opak-Serang can be classified into 3 venography such as

a. Zone of Kulon Progo Mountainous
b. Zone of South Mountainous
c. Depression Zone of Merapi-Merbabu-Sumbing-Sindoro

Distribution of aquifer and Aquiclude zone in study area includes

a. Aquitard zone of Kulon Progo, with the potency of groundwater is small
b. Aquifer zone of Sentolo, with the potency of groundwater is medium
c. Aquifer zone of Wates, with the potency of groundwater is medium
d. Aquifer zone of volcanic, with the potency of groundwater is big
e. Aquitard zone of Baturagung, dengan potensi air tanah kecil
f. Aquifer Wonosari, with the potency of groundwater is big
g. Aquifer zone of Kars and Sungai Bawah Tanah Gunung Sewu, with the potency of groundwater is big enough
h. Aquiclude zone which consists of impermeable stone

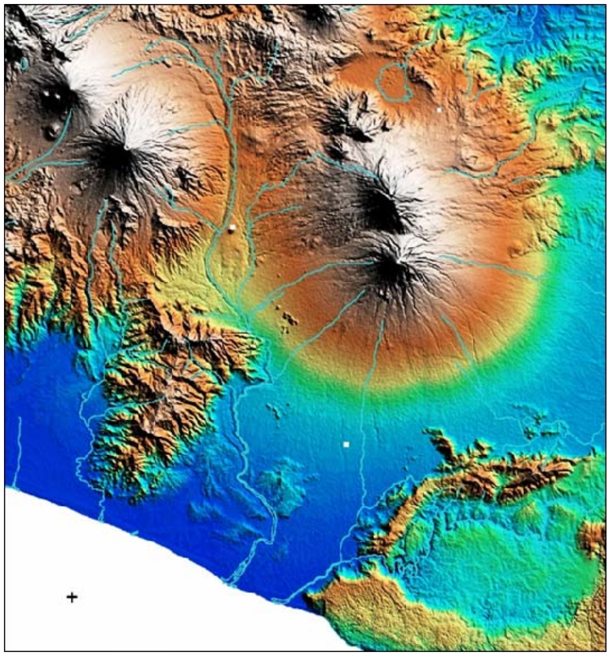


Figure 2 Topography condition of river area on POS

The steps of work are as follow:

1. To inventory and identify the problem on each critical location, water gate, kelp gate, flood dyke, structure on drainage which is also used for the other function such as if there is used for irrigation or other function. The data that is obtained is the dimension as well as the function of the structure.
2. To inventory and identify the happened inundation and primary data when there was rainfall that caused inundation as well as secondary data such as about the dimension of area number and the depth, time of happening, and time of inundation.
3. To study the technical and non-technical problem, result of identification, inventory, and to analyze the available source of problem.
4. The result of identification and the evaluation of the problem above then is set in mathematical form for determining the priority scale due to the scope of study.
5. To analyze the impact which is caused by the inundation such as the loss of material as well as non-material.
6. To quantify the losses factors as well as the other qualitative impact so it can be evaluated and determined the parameter.
7. To carry out the monitoring of flow for measuring the performance of available drainage network infra-structure by observing the capacity of network storage, water level observation, and flow observation tool (Automatic Water Level Recorder/ AWLR), roughness number of wall. Etc.
8. To analyze the data by making the correlation between inundation and drainage network which has certain capacity (V, Q) in flowing the available inundation (ha/m^3) on a certain area.
9. After carrying out the steps as above, there will be produced the real demand value for drainage network infra-structure (Rp./ha or Rp./m^3) [5]
10. To analyze the index of real demand from the study result of drainage performance study [4] which is functioned to flow the inundation on an area where is served by every drainage infra-structure.

Synthetic Unit Hydrograph of Nakayasu

Nakayasu from Japan has formulated the synthetic unit hydrograph and the formula was as follow:

$$Q_p = \frac{1}{3,6}\left(\frac{A\ Re}{0,3\ Tp + T_{0,3}}\right) \quad \text{……………………………………………………….} \quad (1)$$

$$T_p = t_g + 0,8\ T_r \quad \text{………………………………………………………………..} \quad (2)$$

Note:

$tg = 0,4 + 0,058\ L$ for L>15 km

$tg = 0,21\ L^{0,7}$ for L<15 km

$T_{0,3} = \alpha\ t_g$

t_r = 0,5 t_g

Q_P = peak discharge
A = area number of catchment area (km^2)
R_e = effective rainfall
T_p = time from the beginning of flood until the peak discharge of flood (hour)
$T_{0,3}$ = time to peak until 0.3 of peak discharge (hour)
t_g = time concentration (hour)
T_r = time unit of rainfall (hour)
α = coefficient of catchment characteristic (it is estimated as 2)
L = length of main river (km)

Data that is used to analyze the peak discharge besides using the rainfall and discharge, it also uses the other data as physical condition of river, condition of catchment area, and dominant of soil type. By being analyzed the unit hydrograph, so the flood hydrograph for any return period will be able analyzed with the formula as follow:

$$Q_k = U_1 R_i + U_2 R_{i-1} + U_3 R_{i-2} + \ldots + U_n R_{i-n+1} + B_f \qquad (3)$$

Note:
Qk = ordinate of flood hydrograph on time of k
Un = ordinate of unit hydrograph
Ri = netto rainfall on time of i
Bf = base flow

The steps of analysis the distribution of hourly rainfall is presented as in Table 1 below. ….

Table 1. Steps of analysis the distribution of hourly rainfall

Column	Parameter (unit)	Description
[1]	t (hour)	Duration of rainfall
[2]	I (mm/hour)	To be analyzed by using the formula of Mononobe: $I_t^T = \left(\frac{P_t^T}{T}\right) \times \left(\frac{T}{t}\right)^{2/3}$ u for the row of 1 = 1 $I_1^1 = \left(\frac{85,5}{5}\right) \times \left(\frac{5}{1}\right)^{2/3}$
[3]	P comulativef (mm)	Comulative rainfall, column [1] x column [2]
[4]	Δ (mm)	Rainfall per-time interval, column 3 row $_{i+1}$ – column 3 row $_i$
[5]	ABM (mm)	Rainfall distribution by ABM method, the biggest result of column [4] is located in the middle then the next biggest pn the right and left
[6]	Loss (mm)	Rainfall that does not become as surface run-off (1 – C) x column [5]
[7]	P_{eff} (mm)	Effective rainfall, column [5] – column [6]

By using Rational method, there is obtained the unit hydrograph for lateral inflow along the main river (order-1 and order-2) and the distribution of effective rainfall is obtained from the analysis of hourly rainfall distribution. To estimate the flood discharge hydrograph for the certain return period is using the polynomial equation for unit hydrograph. The estimation of flood discharge hydrograph for lateral inflow is presented as in Table 2 below.

Table 2. Analysis of lateral inflow hydrograph with two years return period

Column	**Parameter (unit)**	**Description**
1.	t (hour)	Happening time series
2.	HS (m^3/s)	Unit hydrograph
3.	$Q_{Peff\,1}$ (m^3/s) P_{eff1} = 1,5 mm	Discharge on the beginning rainfall. P_{eff1} x HS

4.	$Q_{Peff\ 2}$ (m^3/s) $P_{eff\ 2}$ = 2,3 mm	Discharge by 1 hour after the beginning rainfall $P_{eff\ 2}$ x HS
5.	$Q_{Peff\ 3}$ (m^3/s) $P_{eff\ 3}$ = 12,6 mm	Discharge by 2 hours after the beginning rainfall $P_{eff\ 3}$ x HS
6.	$Q_{Peff\ 4}$ (m^3/s) $P_{eff\ 4}$ = 3,3 mm	Discharge by 3 hours after the beginning rainfall $P_{eff\ 4}$ x HS
7.	$Q_{Peff\ 5}$ (m^3/s) $P_{eff\ 5}$ = 1,8 mm	Discharge by 4 hours after the beginning rainfall. $P_{eff\ 5}$ x HS
8.	Q_2 (m^3/s)	Flood discharge with 2 returns period $Q_{Peff\ 1} + Q_{Peff\ 2} + Q_{Peff\ 3} + Q_{Peff\ 4} + Q_{Peff\ 5}$

RESULTS AND DISCUSSION

Analysis of Design Flood

Design flood in Indonesia is generally determined based on the analysis of maximum daily rainfall which was recorded. Analysis of design flood in river area of POS was analyzed by using Nakayasu method for the river of order-1 and 2, and then hypothetic unit hydrograph of Rational was used for analyzing the river of order-3 and 4 or the smaller one.

Hypothetic Unit Hydrograph of Rational

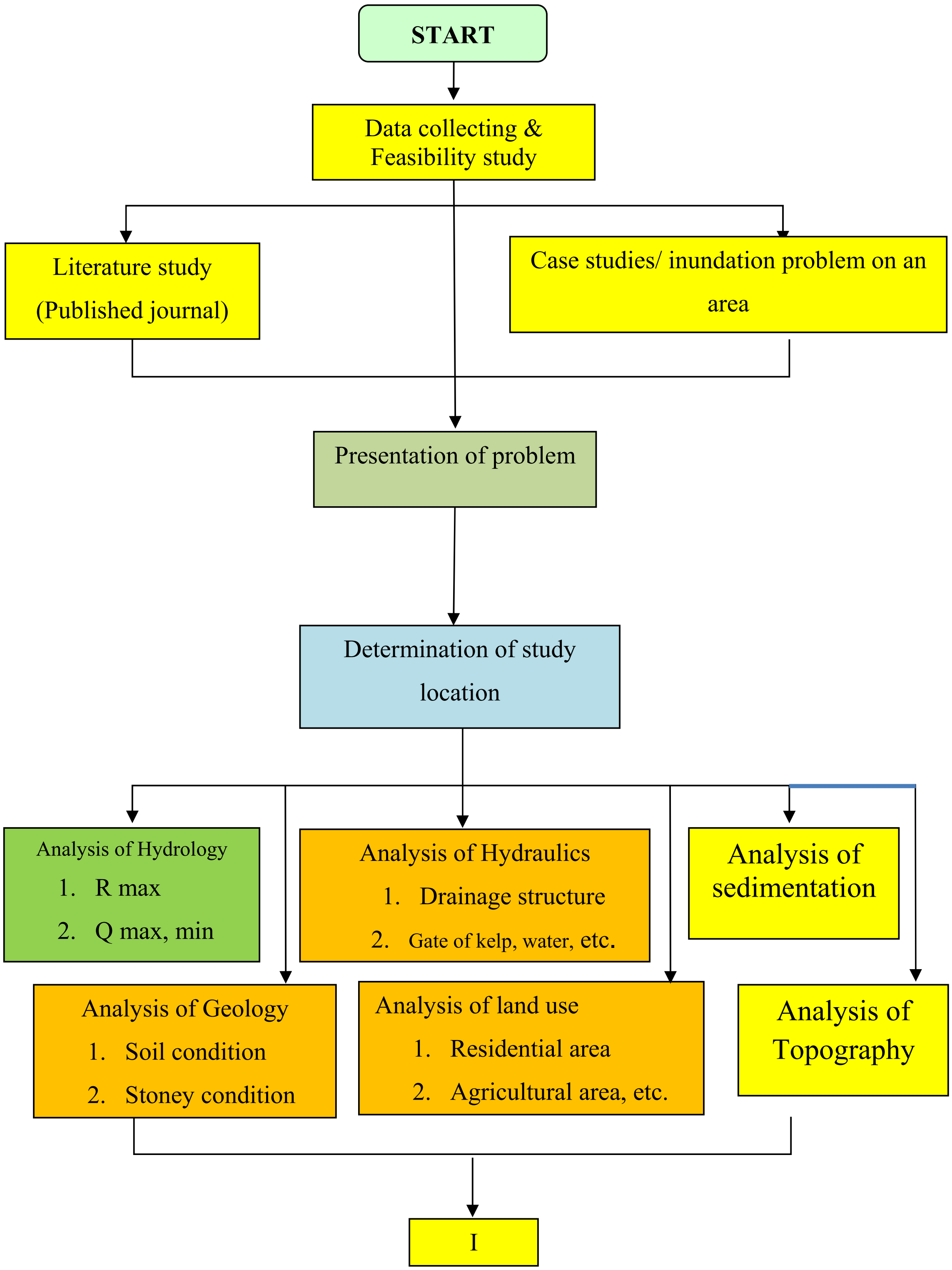
Hypothetic unit hydrograph is used for analyzing design flood on the river of order-3 or the smaller one in area river of POS. Distribution of hourly rainfall which is used for obtaining design flood is using Alternating Block Method (ABM). The consideration is there is no hourly rainfall so the measured rainfall distribution cannot be carried out. Distribution of ABM is a simple way for developing hydrograph (graphic of rainfall intensity or volume as the function of time due to the intensity duration frequency curve. Based on the analysis of rainfall duration from 1985 until 2012, it indicated that the averaged intensity of rainfall is more than 20 mm and total duration of 5 hours.

Based on the analysis using Rational method, it is obtained that unit hydrograph for lateral inflow along the main river (order-1 and 2) and for effective rainfall distribution has been produced through the analysis of hourly rainfall distribution. However, estimating the design flood hydrograph with certain return period is used unit hydrograph method of polynomial equation.

Scenario of modelling real demand value on main drainage infra-structure

The output of data that is produced from this study is real demand value (Rp./ha or Rp./m^3) based on the result of analysis on the drainage infra-structure performance in the scheme of reducing the happenning innundation on an area. To produce the output as above, the steps is presented as in Figure 3 below.

FLOW CHART (1)


START
Data collecting & Feasibility study
Literature study (Published journal)
Case studies/ inundation problem on an area
Presentation of problem
Determination of study location
Analysis of Hydrology
1. R max
2. Q max, min
Analysis of Hydraulics
1. Drainage structure
2. Gate of kelp, water, etc.
Analysis of sedimentation
Analysis of Geology
1. Soil condition
2. Stoney condition
Analysis of land use
1. Residential area
2. Agricultural area, etc.
Analysis of Topography
I

FLOW CHART (2)

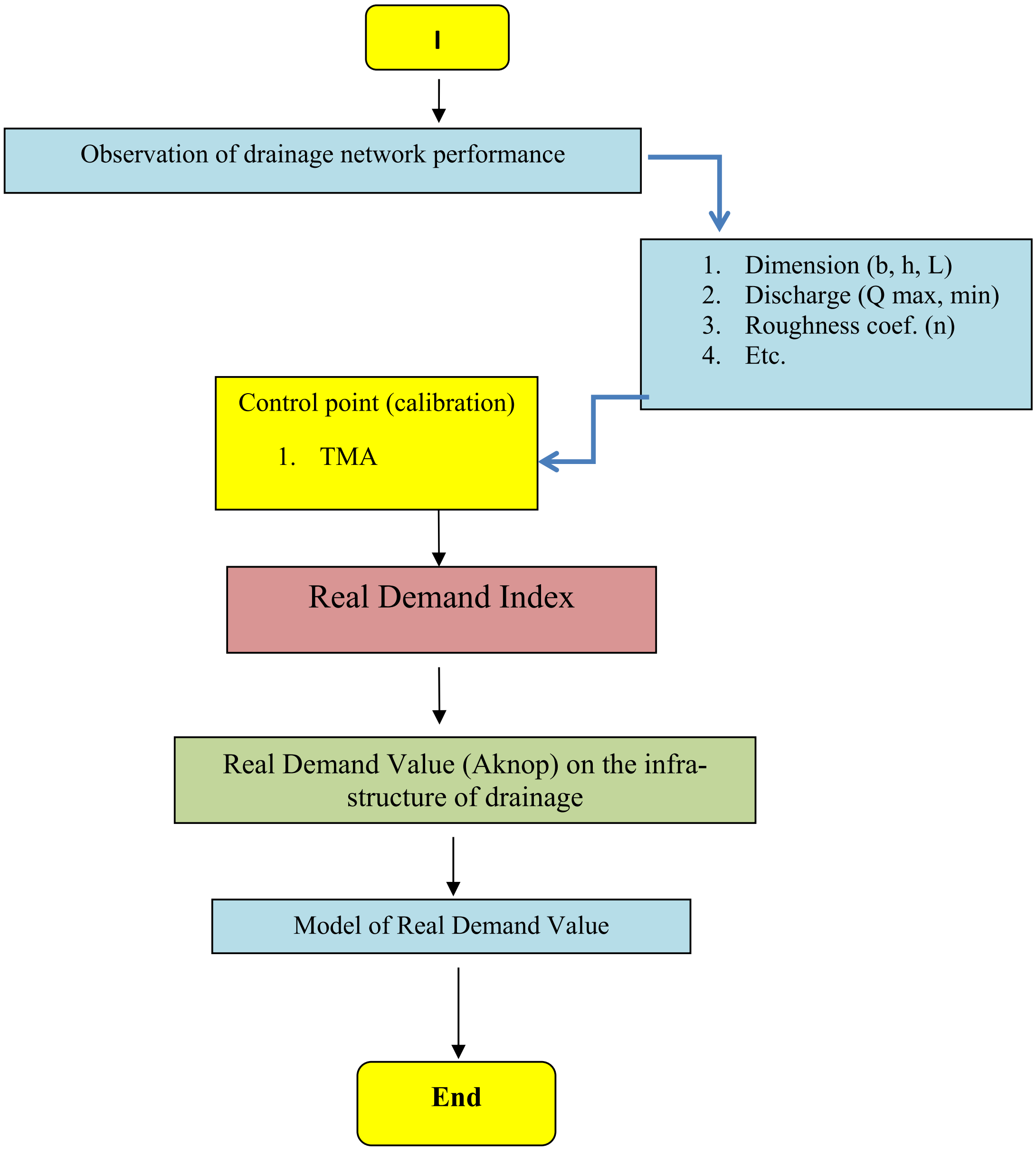


Figure 3. Scenario of modelling real demand value on main drainage infra-structure

CONCLUSION

Based on the analysis above, the scenario is made for analyzing the real demand value of operation and maintenance on the main drainage infra-structure. It is to be produced an index that can be used to measure accurately as an evaluation of a drainage network infra-structure performance. It is to help accurately on making policy decision in handling the drainage infrastructure. It is to help accurately on making policy decision so the handling is on time, on quality, and on target.

REFERENCES

1. Ida Ayu Asrana Dewi, IGN Kerta Arsana, IGN Oka Saputra. 2013. Analisa Kapasitas Saluran Drainasi Sekunder dan Penanganan Banjir jalan Gatot Subroto Denpasar. *Jurnal Ilmiah Elektronik Infrastruktur Teknik Sipil*, Vol. 2 No. 2, April 2013: XV-1 – XV-5

2. Sih Andayani, Bambang F. Yuwono, Soekrasno. 2012. Indikator Tingkat Layanan Drainasi Perkotaan. *Jurnal Teknik Sipil,* Vol. 11 No. 2, April 2012: 148-157

3. Dan Yin, Longcang Shu, Xunhong Chen, Zhenlong Wang, and Mokhatar Eisa Mohammed. 2011. Assessment of Sustainable Yield of Karst Water in Huaibei, China**,** *Water Resource Manage* 25:287–300

4. Anna T. Straton, Sue Jackson Oswald Marinoni, Wendy Proctor, and Emma Woodward. 2011. Exploring and Evaluating Scenarios for a River Catchment in Northern Australia Using Scenario Development, Multi-criteria Analysis and a Deliberative Process as a Tool for Water Planning. *Water Resource Manage* 25:141–164

5. A.P. Demin. 2010. Changes in Water Dependence of Russian Economy*, Water Resources, 2010, Vol. 37, No. 6, pp. 862–873*. © Pleiades Publishing, Ltd., 2010