The real operational cost for managing Semarang river polder drainage system

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Abstract: To resolve tidal flood and flooding problem, the Semarang city government has made various efforts such as building reservoirs in the upstream area, normalizing the rivers, developing polder drainage systems, and preventing sea water intrusion by building sea dike and river embankments. The method is quite effective to prevent the occurrence of rob (tidal flood), but water from the upstream area cannot flow by gravity to the sea. Water flows from upstream through the canals into a retention pond, and then pumping it into the sea. The Semarang River drainage polder system consists of some rivers (Semarang River, Asin River, Baru River), Retention Pool and Pump Station at the mouth of the Semarang River. Sustainability of the polder system requires an effective system of operation and maintenance. This study aims to determine the real need cost for a good operation of the Polder Drainage System. The research method used is quantitative description analysis. Data collection techniques using interviews, observation, and document review. The result show that budget component consists of fuel consumption, electricity, lubricants, spare parts, services, and inspection step. The difference in the amount of financing each year is due to fluctuations in rainfall intensity per month, the combination power supply by electricity and generator.

1. Introduction
Semarang city is a metropolitan city with population of ±1.7 million. As a metropolitan city located in a coastal area, the city of Semarang has a drainage problem that is identical to several Central Java north coast areas, namely tidal flood (rob) and flood. Floods mainly occur in the rainy season, due to large discharges exceeding the cross-sectional capacity of drainage system [1]. This is caused by sedimentation and waste water from the upstream watershed or its sub-watershed. Besides sedimentation, the decline in function and capacity of rivers and urban drainage. There is also caused by illegal buildings on the banks or even river bodies or channels, which reduce the function of the overflow capacity of the river [2].

Other problems affecting the drainage system in the coastal area of Semarang City are the phenomenon of tidal flood (flood due to tides), saltwater intrusion in the lower Semarang City, land subsidence that is local impacts of the ongoing process of land consolidation in the coastal area where the coast is generally composed of alluvial compressive layers [3].
To deal with the problem of tidal flood and flooding that occurred in the city of Semarang, the Semarang city government has made various efforts such as building reservoirs and reservoirs in the upstream area as water conservation efforts. They work to normalize the rivers, to enlarge the capacity of the reservoir and to facilitate the water flow, and to develop some polder systems drainages. To prevent sea water entering the land, they build sea dike, gate and river embankments. The construction of sea dike that have been carried out in the city of Semarang. The drainage is for the ditch that was built aiming at facilities for the basic needs of planning or designing an urban infrastructure area [4]. Drainage development is one of the city’s infrastructures based on environmentally friendly concepts [5].

Drainage design is based on the philosophy that water flows as fast as possible and inundates the service area to a minimum. To increase good water balance (usage and availability), a philosophical drainage design is needed not only safe from inundation but also at the same time for water conservation [6]. The Implementation of urban drainage systems explained that the operational activities for polder systems include planning, implementation, monitoring and evaluation activities [7]. Operational infrastructure and facilities for polder drainage systems are carried out to optimally regulate the flow of water and sediment management including the activities of opening and closing water gates, cleaning trash in the trash rack, turning the water pump off, and regulating water flow.

The polder system is a water management subsystem which is expected to be democratic and independent that is developed and operated by and for the community in terms of flood control in residential areas [8]. The most important elements in a polder system are the management organization, a system of governance based on community participation that is democratic and independent, and water management structures that are designed, operated and maintained by the community.

With the operations management polder drainage system can be obtained an overview of the actual field conditions and financing items. The polder drainage need a guideline for operational management systems and can be used as a reference for other systems [9]. Therefore, the procedure for preparing the real needs management operational of the polder drainage system must be prepared in accordance with local conditions based on applicable legal principles in order to contribute to the achievement of the overall drainage system management objectives with an example of the Semarang River system.

2. Data and method
The research method is based on a quantitative research approach that is by collecting data in the form by questionnaire and choice questions which are then analyzed quantitatively (inference). This research approach is also integrated qualitatively with data collection in the form of sentences, descriptions, through interviews or go directly to the field and supported by photo documentation. Field observations were made in the Semarang river polder drainage pump station. In this research, we collected all the data needed to be analyzed quantitatively and qualitatively, to be able to formulate and arrange scientific conclusions. In this study the research instruments were the researchers themselves (human instruments), primary and secondary data [10]. The human instrument serves to determine the focus of the study, select informants as data sources, conduct data collection, assess data quality, analyze data, interpret data, and make conclusions [11].

3. Results and discussion
3.1 Semarang river drainage system
The Semarang Central Drainage System has low land in the north and hilly areas in the south. The drainage system area has a catchment area of 2,307 ha and is bordered by the Java Sea to the north, the West Flood Canal to the west, the East Flood Canal to the east and Mount Ungaran to the south. Primary channels in the Central Semarang Drainage System include the West Canal Flood, Bulu channel,
Semarang River, Baru River and Banger River. There is cross drain (belt channel) that holds water from the upstream area and flows it to the West Flood Canal and East Flood Canal.

![Figure 1. Schematic of Central Semarang drainage system and discharge distribution.](image)

The Central Semarang drainage system is divided into 7 (seven) sub-systems, namely Bulu River Sub-System, Asin River Sub-System, Semarang River Sub-System, Baru River Sub-System, Bandarharjo River Sub-System, Simpang Lima River Sub-System, and Banger River Sub System [12].

| No | Sub System            | Sub System Area (ha) |
|----|-----------------------|----------------------|
| 1  | Bulu River            | 93.57                |
| 2  | Asin River            | 281.35               |
| 3  | Semarang River        | 576.28               |
| 4  | Baru River            | 185.55               |
| 5  | Bandarharjo River     | 302.07               |
| 6  | Simpang Lima River    | 340.3                |
| 7  | Banger River          | 523.79               |

Semarang River has 576.28 ha of catchment area. Currently Semarang River is also the estuary of Asin River, Baru River and Bandarharjo River. Based on the previous survey, inundation in the Semarang River sub-system is about 30% of total area

3.2 **Semarang river sub-system infrastructure components**

3.2.1 **Pump and generators.** The runoff from some of the canals is pumped through retention basin and outflows into the Java Sea. The drainage system is planned for a 5 year flood return period [13]. Number
of Pumps installed Pumps with a capacity of 5 m³/sec are 6 units; Pumps with a capacity of 2.5 m³/sec are 2 units. The small capacity pumps are used during daily operations in the dry season.

![Figure 2. Semarang river pump and generators.](image)

Pump inlet elevation is at 3.0 m sea level, this elevation is chosen so that the pump still can be operated when the water level is at its lowest. While the maximum elevation that is maintained is +0.5 m. From the research results it can be known that the pump resources were using electricity and generators. For generators there are the capacity of 2,250 kVA (2 units) for large generators, 1,000 kVA (1 unit) and 180 kVA (1 unit) for small generators.

3.2.2 Retention pond and trash rack. This retention pond construction is located at the mouth of Semarang River with an area of 68,000 m² (6.8 ha), water storage capacity of 238,000 m³, elevation base is at EL = -3.5 m, embankment elevation is +4.00 m. Planning sea level tide level with consideration of land subsidence at +3.5 m, Free board of 0.5 m, embankment around the 1250 meters of retention pond. At present observation, the retention pond capacity has decreased by 30% from the initial capacity.

![Figure 3. Retention pond and trash rack.](image)

The trash rack construction plays an important role because it affects the pump performance system. The trash rack construction consists of upstream trash rack with 51 meters’ length and 10 meters’ height, a total of 11 units of garbage catchers. The drive of this trash rack system can be automatically or manually. The trash rack structure can be seen in figure 3. It is the structure under the bridge.
There is floodgate that border from sea water. The floodgate will be functioned or opened if there is an emergency situation due to extreme rainfall intensity. Until now the floodgate at Semarang River Drainage has never been used since the construction built, because the sea level has higher elevation than the Semarang river area water level.

3.3 Operational cost analysis
Operations and Maintenance (O&M) activities are two different activities, but they cannot be separated because each other influences one another. In terms of engineering maintenance can be defined as the art of maintaining equipment, buildings, and other related facilities, for providing service to be conducive condition [14]. The operation of a drainage system requires not only physical operation of various components, but its operation in an emergency and on-call condition. Operational financing can be divided into constant and dynamic categories.

3.3.1 Constant Operational Costs. Results of the study obtained data on the operation of the Semarang River Pump Station which is constant every month, including replacement of parts, service and inspection (monitoring) activities. The following data are for the last 3 (three) years operation from 2017 to 2019.
1) Replacement Parts Financing
The cost of replacing parts at the Semarang River Pump Station from 2017 to 2019 every month per year is relatively increasing. The amount of costs required for 2017 was IDR. 12,000,000.00, for 2018 was IDR. 24,000,000.00, and for 2019 was IDR. 36,000,000.00. From these results it can be concluded that there is a trend of increasing for replacement parts financing each year.
2) Service Financing
Service financing at Semarang River Pump Station from 2017 to 2019 every month per year is constant. The recapitulation of service costs required for 2017 and for 2018 are IDR. 24,000,000.00 while service fees for 2019 are IDR. 36,000,000.00.
3) Inspection / Monitoring Activities Financing
The financing of Semarang River Station Pump inspection activities from 2017 to 2019 every month per year are increasing, because the cost of each activity per month uses a lump sum calculation. The recapitulation of costs required for 2017 is IDR. 24,000,000.00, for 2018 is IDR. 30,000,000.00, and for 2019 is IDR. 36,000,000.00. From these results it can be concluded that each year there is an increasing trend of financing needs for inspection activities.

3.3.2 Dynamic Operational Financing Analysis. In operating the Semarang River Polder Pump System, there is a large amount of funds each month, namely operational fuel financing, operational financing for electricity usage, and operational financing for oil / lubricant used.
1) Fuel Operational Financing
The trend of fuel operational cost needs from 2017 to 2019 has the same pattern, namely in the rainy season and then the trend decreases in the dry season. From the data obtained above, it can be concluded that the highest operational costs occur in the rainy season and the lowest operational costs occur in the dry season. They need low cost on June to August about IDR. 40,000,000.00, and peak cost in December during the season rain about IDR. 200,000,000.00. In the rainy season the pump works 24 hours nonstop so it requires a large operational cost. Whereas in the dry season the pump works only when needed, so the operational costs are relatively low.
2) Electricity Operational Financing
In 2017 the highest electricity operating costs occurred in December amounting to IDR. 138,450,855.00 and the low electricity operating costs occurred in February, March, July, August, September, October, November with the same expenses as IDR. 114,772,924.00. In 2018 the highest electricity operating costs occurred in March amounting to IDR. 227,755,807.00 and the low electricity operating costs occurred in June, July, August, September, October, November, December with the same cost of IDR. 114,772,924.00. In 2019 the highest electricity operating costs occurred
in April amounting to IDR. 238,476,519.00 and the lowest electricity operating costs incurred in February of IDR. 114,113,786.00.

From the data obtained above, it can be concluded that the operational costs of electricity do not have much influence with the seasons, because each month the demand for electricity is relatively the same. The energy needs beyond that are supported by the operation of generators that use fuel as discussed previously.

3) Oil / Lubricant Operating Financing

From the graph in figure 6, it is obtained that in 2017 the highest operational costs for oil / lubricant use occurred in January, February, March, April with the same cost of IDR. 82,624,000.00 and the lowest oil / lubricant operating costs incurred in October, November, December with the same expenses of IDR. 62,848,000.00. In 2018 the highest operational costs for oil / lubricant use occurred in January, February, March with the same costs of IDR. 57,037,500.00 and the lowest operating costs for oil / lubricant use occurred in August, September, October, November, December with the same cost of IDR. 48,945,000.00. In 2019 the highest operational costs for oil / lubricant use occurred in January, February, March, April, May, June with the same costs of IDR. 52,710,000.00 and the lowest operating costs for oil / lubricant use occurred in December at a cost of IDR. 26,390,000.00.

The trend of operational costs for the use of oil / lubricant in 2017 from the beginning of the year to
the end of the year has relatively decreased, the trend of the need for operational costs for the use of oil / lubricant in 2018 from the beginning of the year to the end of the year has decreased but is relatively flat, whereas in 2019 since the beginning of the year has decreased until the end is similar to the 2017 trend.

3.3.3 Recapitulation of Real Operating Costs. The Operation and Maintenance (O&M) activities are two different activities but cannot be separated, because they influence each other [11]. The results showed Operation cost of Semarang River Polder drainage system in 2017 of IDR. 3,66 billion; in 2018 IDR. 4,03 billion; in 2019 IDR. 3,13 billion with cost components consisting of fuel operational financing, electricity operational financing, oil / lubricant operational financing, parts replacement financing, service service financing, and financing for inspection / monitoring activities. The results showed that the difference in the amount of financing each year was different due to the fluctuations of rainfall intensity per month.

4. Conclusion
Based on the existing conditions of the Semarang River Polder Drainage Pump Station, as well as from the results of the analysis conducted, several conclusions can be drawn as follows:
1. The pump is still in good condition where overall 8 pump units with a capacity of 35 m3 / sec. The operation of the Semarang River Polder Drainage System Pump Station is carried out by working steps by checking the availability, supplying of fuel to the generator set, checking the electrical panel and pump start panel, operating the pump.
2. The results of analysis of the constant cost for Operational process. The cost of replacing parts for 2017 is IDR. 12,000,000.00; in 2018 IDR. 24,000,000.00 and in 2019 IDR. 36,000,000.00. The need for services financing increases every year due to an increase in labor costs and along with the decline in equipment function, service activities will increase. The need for financing inspection activities has increased due to an increase in honorarium.
3. The results of the dynamic cost analysis. The fuel operational costs for 2017 amounting to IDR. 1,314,695,621.00 for 2018 IDR. 1,794,200,340.00 and for 2019 IDR. 915,965,130.00. The need for the highest operational fuel costs occurs in the rainy season and the lowest operational costs occur in the dry season. The electricity operating costs in 2017 of IDR. 1,442,881,262.00, in 2018 IDR. 1,546,093,090.00 and in 2019 IDR. 1,618,653,366.00. The electricity operational costs is not too influential with the seasons, because every month electricity needs are relatively the same. The
8

operational costs for the use of oil / lubricant in 2017 is IDR. 847,360,000.00; in 2018 IDR. 616,817,500.00 and in 2019 amounting to IDR. 496,160,000.00.

4. The Real operation cost of the Semarang River Drainage System Pump Station in 2017 is IDR. 3,664,936,883.00, in 2018 is IDR. 4,035,110,930.00 and in 2019 is IDR. 3,138,778,496.00. The difference in the amount of financing each year is due to fluctuations of rainfall intensity per month and per year.

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