CRBOM Small Publications Series No. 16

The Banger polder in Semarang

by

Herman Mondeel and Hermono S Budinetro

Center for River Basin Organizations and Management,
Solo, Central Java, Indonesia

January 2010

The *'Small Publications'* are intended for knowledge-sharing and dialogue. In some cases they may present facts, information and lessons learnt. In other cases, they provide news, opinions, ideas or open questions for discussion.

They express the opinions of the author(s) and not those of CRBOM.

They can be freely copied and disseminated.

Contributions are most welcome - in English or in Bahasa Indonesia.

The authors:

Herman Mondeel, Project Leader, Witteveen+Bos, H.Mondeel@witteveenbos.nl
and
Hermono S Budinetro, Deputy Director (Information and Technology), CRBOM, hermonob@crbom.org

CRBOM
Center for River Basin Organizations and Management,
Solo, Central Java, Indonesia
www.crbom.org
info@crbom.org

Contents

Location map i
Summary ii
Acronyms and abbreviations ii
1 Introduction 1
2 Background 1
3 The polder concept 1
4 Design optimization 2
4.1 Safety level 2
4.2 Water level control 4
4.3 Pump capacity and retention capacity 4
5 Conclusion 5

Location map

Summary

Many of Asia's cities are located in low areas near the coast and are exposed to flooding and poor drainage. The exposure can escalate due to land subsidence or climate-related changes of rainfalls, floods and sea level.

The present paper describes a viable adaptation scheme, the polder. A polder is an area, surrounded by a closed ring of flood protection elements (dykes and dams) to separate the water regime inside the polder area from the water regime outside. The water table inside the polder is controlled by tidal gates and/or pumping stations.

The example provided is from Semarang, Central Java, a low-lying town with some 1.4 mio. inhabitants. The town is severely affected by floods from the sea as well as floods caused by direct extreme rainfall. The Banger area, named after its main channel, covers 550 ha with 84,000 inhabitants. The present land elevation is around Mean Sea Level, but with a land subsidence of 9 cm/year the area is progressively sinking below the sea.

The polder concept has been identified as a feasible way to alleviate the flood and drainage problems in the area, with benefits favourably exceeding the costs.

Acronyms and abbreviations

Bappeda:	Badan Perencanaan Pembangunan Daerah (provincial development planning board)
BBWS:	Balai Besar Wilayah Sungai (river basin organisation)
PSDA:	Peneglolaan Sumber Daya Air (water resources management unit)

1 Introduction

Many of Asia's cities are located in low areas near the coast and are exposed to flooding and poor drainage. The exposure can escalate in case of land subsidence or climate-related changes of rainfall and flood incidence, not to speak of a sea level rise.

The present paper describes a viable adaptation scheme, the polder. Applied in the Netherlands (and elsewhere) for centuries, a well managed polder can reduce (if not eliminate) flood- and drainage-related impacts. The example provided is from Semarang, Central Java, a low-lying town with some 1.4 mio. inhabitants and exposed to severe land subsidence.

2 Background

The Banger area is named after the main channel in the area: The Kali Banger. The area covers 550 ha with 84,000 inhabitants. Today, the water level in this area is determined by the sea with inflow during high tide and outflow during low tide. The present land elevation is around Mean Sea Level (MSL), but with a land subsidence rate of 9 cm/year the Banger area is progressively sinking below the sea.

Due to the subsidence, flooding in Semarang is increasing in frequency and severity. There are two causes:

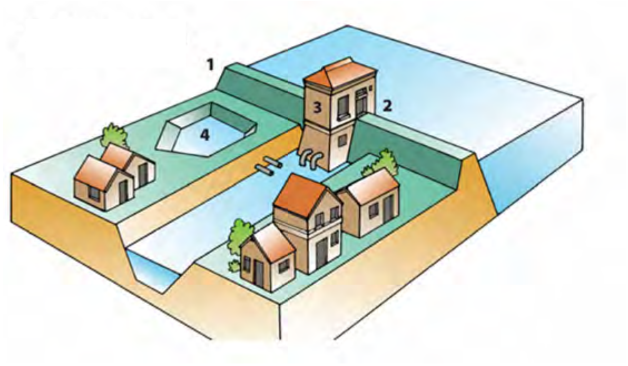
- Floods caused by high water level outside the polder *(rob);* and
- inundation caused by heavy rainfall *(banjir).*

Both types of flood are amplified by land subsidence: The former because the coastal area is progressively subsiding below sea water level, and the latter because the discharge of the rainfall is blocked by high water levels in the Kali Banger. Expansion of paved areas and negligence of maintenance and clogging of the existing drainage infrastructure increase the inundation. Climate change will further worsen the situation due to sea level rise and increased rainfall in the wet season.

3 The polder concept

The polder concept has been identified as a suitable solution to resolve the current problems with flood and inundation in Semarang. A polder is an area, surrounded by a closed ring of flood protection elements (dykes and dams) to separate the water regime inside the polder area from the water regime outside. The water table inside the polder is controlled through structures (tidal gate and/or pumping station).

Figure 1: The elements of a polder



1 Closed dyke-ring, to protect from *rob*
2 Dam, to close the river. The dam is part of the dyke-ring
3 Pumping station, to discharge the rainfall and to control the water level inside the polder
4 Retention basin

The polder system requires an integrated approach:

First of all, an integrated approach to all elements that constitute a polder (pumping station, dykes, retention basin, channels). The polder can not function properly without one of the elements;

secondly, it requires an integrated approach with all stakeholders - like PSDA, Bappeda, BBWS and land owners;

thirdly, it requires an integrated approach in some technical aspects, such as defining the safety level, the water level to be controlled, and retention and pump capacity, since all these aspects are related to each other.

The technical aspects are explained below.

4 Design optimization

4.1 Safety level

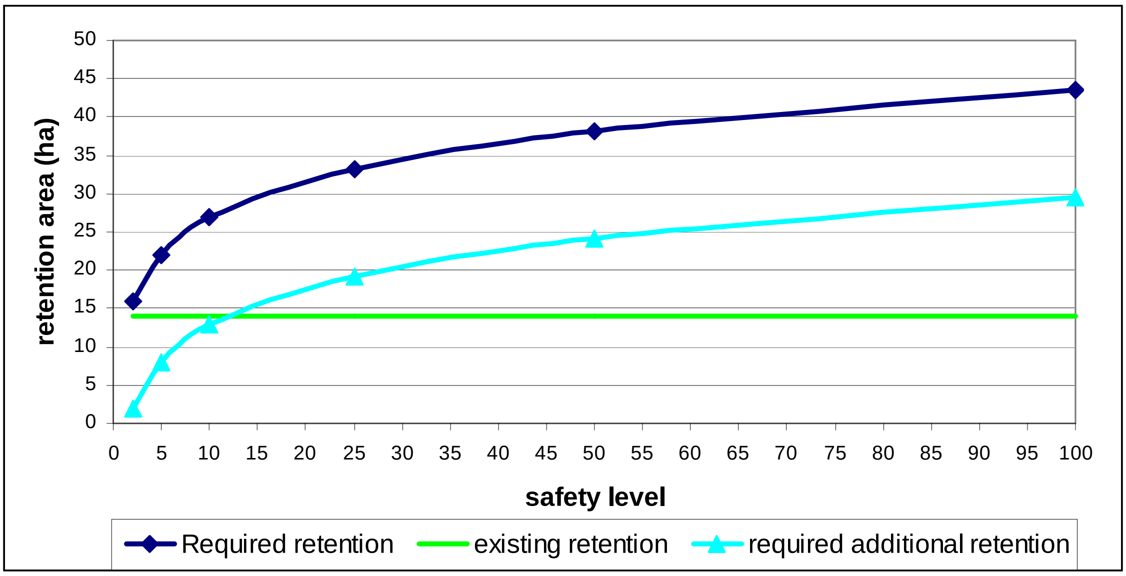
The safety level of dykes and the water management system is expressed as the return period T. A dyke with a safety level T10 means that, on the average, the dyke will overtop or break once every 10 years.

There are two safety levels. One for flood caused by the sea *(rob)* and one for floods caused by rainfall *(banjir).* The *rob* can reach high inundation levels (a meter or more) and subsequently higher damage. The *banjir* is limited to the volume of the rainfall within the catchment area, resulting in lower inundation levels (centimetres to decimetres).

An economic assessment has been carried out to determine the optimal safety levels.

A simple approach has been applied for assessment on the internal water management system (for protection against *banjir)*, comprising the pumping station, the retention basin and the main channel. Hereby, the safety level is linked to the area of the retention basin. A larger retention basin is more expensive, but will also provide a higher safety level, resulting in less (economic) damage.

Figure 2: Retention area and safety level for internal water management system

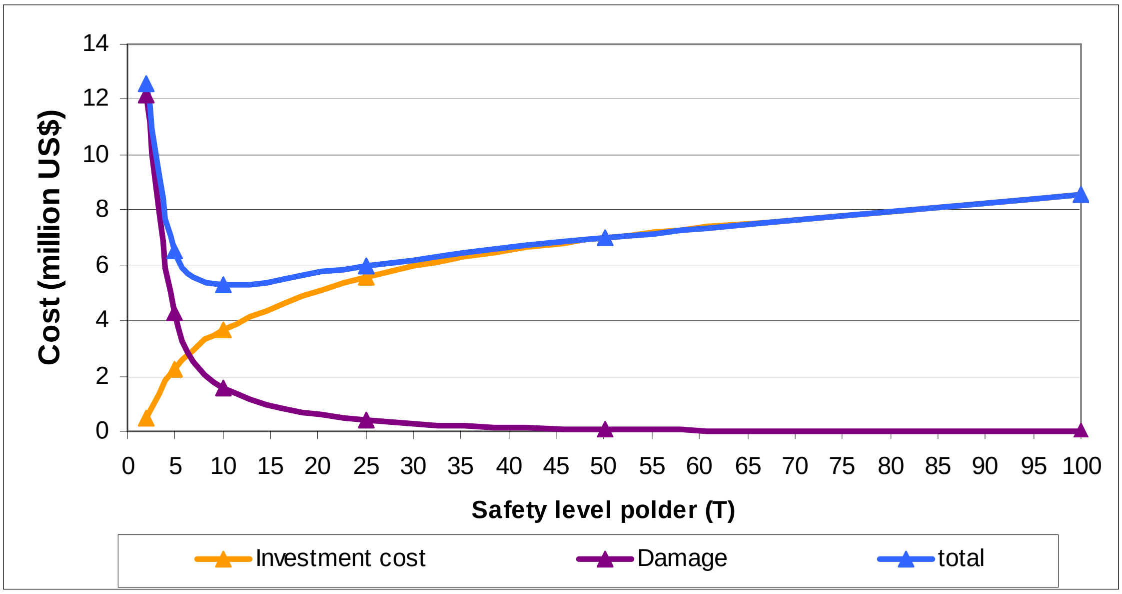


A higher safety level not only results in a lower frequency of inundation, but also in a lower inundation depth and damage. The first step in the assessment is therefore to determine, for different safety levels, the flooded areas and the inundation depth. The inundation depth can be translated to damage (direct, indirect and intangible), based on the value of assets, time lost in traffic and production processes, and health impacts.

By comparing the Net Present Value (NPV) of (additional) investment costs, operation and maintenance costs and the reduced damage, the optimal safety level has been determined to 10 years (T10).

For the dykes a higher safety level (of T10,000) is optimal. This is because a much higher safety level can be obtained with a relatively small additional height.

Figure 3: Additional investment cost and damage, internal water management system



4.2 Water level control

The pumping station controls the water level in the channels and hereby also the groundwater level. To determine the optimal water level, a comparison has been made of the groundwater level, the settlement caused by lowering the groundwater level, and the related retention capacity.

To keep the groundwater level sufficiently low in the rainy season, the water level needs to be 1.25 to 1.5 m below surface level in order to maintain a groundwater level of 0.75 to 1 m below surface level. With this (low) groundwater level, the soil provides sufficient bearing capacity for roads and buildings, resulting in less damage, and flooding of buildings is avoided.

The controlled water level also determines the retention capacity of the channel and the retention basin. To increase this capacity, a water level of 2 m below surface level has been selected. Hereby, the water can rise 2 m during an extreme rainfall without causing problems.

On the other hand, a lower groundwater level causes additional settlement of the soil. The settlement is 2 mm/year in case of a lowering of the water level to 2 m below surface level. This rate is regarded as acceptable, considering that the present land subsidence is 9 cm/year.

The chosen water level and retention capacity relate to determination of the safety level, because the water level determines the size of the retention basin and hereby the costs.

4.3 Pump capacity and retention capacity

The pump capacity and the retention capacity interact to withstand extreme rainfalls: The higher the pump capacity, the smaller the required retention area, and - the other way around - a larger retention area requires less pump capacity. A minimum discharge capacity is required to discharge the rainfall before the next rainfall event. As a rule of thumb the rainfall of a T1 rainfall event (yearly maximum) should be discharged within 24 hours.

The optimal balance between pump capacity and retention capacity is assessed based on investment and operation and maintenance costs.

Figure 4: Pump capacity and retention capacity

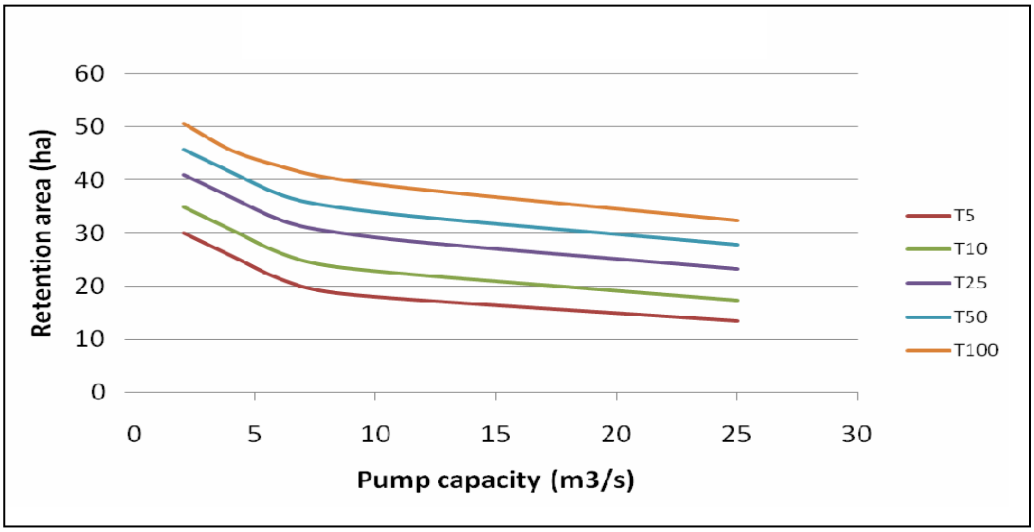
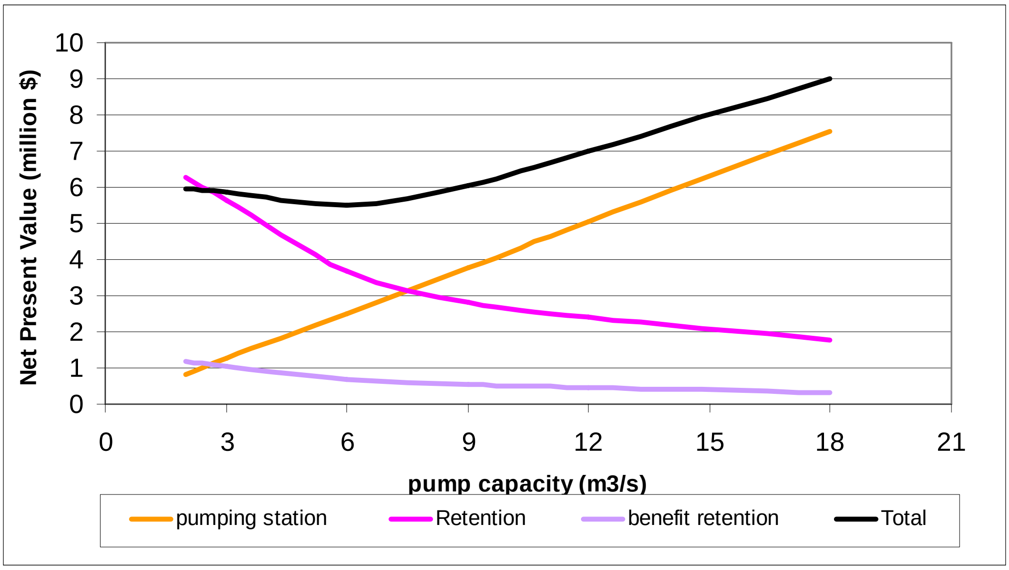


Figure 4 shows the relation between pump capacity and retention capacity for several safety levels. The economic optimal safety level for the internal water management system is T10, as described above. The water table is determined as 2 m below surface level, as described above, whereby the retention capacity in m3 can be expressed in hectares.

The assessment of the retention and pump capacity is based on a Net Present Value for a lifetime of 50 years. This assessment is based on investment costs for a pumping station (expressed per m3/s) and retention basin (m2), land acquisition and resettlement costs, and operation and maintenance costs. The retention basin provides additional benefits because it can be used as fishpond; this has been taken into account as well.

Figure 5 presents the Net Present Value of the investment of the pumping station, the retention basin, the yearly benefits, and the total. The optimal pump capacity is 6 m3/s. With a catchment area of 550 ha, this is equal to 11 litres/s/ha. The required retention area is 26 ha, or 5% of the area.

Figure 5: Net Present Value



5 Conclusion

A polder system is an integrated system of elements, comprising the closed ring-dyke, pumping station or sluice, retention basin, etc. The polder can not function properly without any of these elements.

Design of the elements needs a integrated approach of the whole polder system first, such as determining the safety level and the optimal pump capacity and retention capacity. Besides the technical issues, the polder system requires an integrated institutional approach as well, since many institutional and private stakeholders are involved. With such an integrated approach, a sound polder system can be designed, protecting the inhabitants from *rob* and *banjir,* and significantly reducing the (yearly) damage.

Center for River Basin Organizations and Management,
Solo, Central Java, Indonesia
www.crbom.org, info@crbom.org