A water system analyses focussed on drainage which shown the obliged in cooperation.

The needed collaboration between kota and kabupaten Pekalongan to solve the inundation problem.

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ABSTRACT

Pekalongan is a city in the north of central Java, with some serious inundation problems. Water flows into rural and urban area due to connections between rivers and canals that are influenced by the tide of the Java sea. A bad drainage system does not allow to drain water and the areas get inundated. The research concentrated on how the water system works, the possibilities to drain water using gravity and how stakeholders work together. The researched location was on the border of the city and regency of Pekalongan. The researched area could be divided into four different areas with each its own sub systems. Measurements showed that draining water using gravity is still possible for certain sub systems. But a long term strategy where stakeholders work together is needed to fully solve the inundation problems in Pekalongan.

Introduction

Pekalongan, the batik city of the world, is located in the North of Central Java as seen in figure 1 (Allo & Piliang, 2015). Pekalongan can be dived in kota, the city part, and kabupaten, the regency. Both areas with their own management (Malisius, 2016). Pekalongan has numerous, agriculture, aquaculture and mangroves but the city also has to deal with some serious inundation problems (Marfai, 2014).

To begin with land subsidence which due to groundwater extraction occur (Wilms, 2016). Groundwater is extracted to use as tap water and for the (batik) industry. The speed of the land subsidence varies from 1.8 to 3.9 centimetres per year (Pramudyo & Wafid, 2015). Due to land subsidence and coastal erosion the city loses fertile soil to the sea. The coast already moved 10.5 meters in land and it is predicted that the coastal erosion keeps going on because of the rising sea level (Marfai, 2014).

Furthermore there is a lack of maintenance to the water infrastructures and water ways. For example many intakes, water infrastructures which can open and close to manage the amount of water, are broken and cannot block water anymore. And the drainage system does not function well due to littering and water hyacinths which cause clogging. Due to clogging the water speed is reduced.

At last and most importantly several connections with rivers and fishponds are causing diurnal inundations in Pekalongan ranging from 30 centimetres in the north to 10 centimetres further south. These connections, such as bridges and intakes allow sea water to flow in during high tide. The connections are made because the fishponds need fresh water to grow fish. The problem is that the fishponds are connected with the inhabited area, which causes inundation. Water from kabupaten flows into kota Pekalongan and vice versa. A serious problem is that kota and kabupaten only focus within their own borders, where water does not follow these administrational borders.

The Dutch waterboard Schieland and the Krimpenerwaard asked the student to do research about the water and drainage system of Pekalongan. This was questioned because the waterboard did not have much information about Pekalongan and was curious of draining water using gravity could be used to reduce the inundation problem. The focus was on the northern border area, if kabupaten or kota is mentioned this means not the whole area but just the northern border area. The border area was chosen because the waterboard already suggested the idea that the water was crossing the border and cooperation was needed. It is especially difficult to find solutions in the border area for the inundation problem because kota and kabupaten then need to cooperate. The researched area is shown in figure 2. The main research question as researched is as follow, *“Where in Tirto and kota Pekalongan are the possibilities to drain water using gravity and (present) water infrastructures?”.* The question would provide an overview of the water system and the possibilities to drain water to reduce inundation in the current situation.

Figure 1 Location Pekalongan on Java, Indonesia.

Figure 2 Researched location in red with the border line in green.

Materials and Methods

The research can be divided in several stages, prelimimanry investigation, interviews in Jakarta, activities in Semarang, fieldwork and surveys in Pekalongan. After the fieldwork and surveys in Pekalongan a circle starts between Semarang and Pekalongan. Where the process of data collecting and data processing follow each other. Each stage contains its own methods to gather information to eventually answer the main research question.

Preliminary investigation was done at the waterboard in the Netherlands. Several interviews with experts on water system analyses, water quality and operating in different cultures were done. Furthermore data collecting and viewing that the waterboard already had about Pekalongan was executed. This led to reports and photos. By analysing these a first suggestion of the situation could be made.

Two interviews were held in Jakarta. The first interview was with Indhira Meliala from Nuffic NESO. Information about the cultural differences and ways to adapt to Indonesian culture was obtained. The other interview, with Tom Wilms from Witteveen and Bos was about the water related problems in Pekalongan.

After this the activities in Semarang started. These activities contained, literature studies, preparation of fieldwork and processing the collected data. Literature was found by doing research on the internet. This resulted in information about the water system and history of Pekalongan. The preparation of fieldwork was performed to make the fieldwork as efficient as possible. To do this several tools were used. At first my maps was used to pinpoint the locations and to make notes at the pinpoint. Second Google Forms was used to create a survey. This survey consisted several questions about the specific water infrastructure or waterway to document information about it. Information such as name, owner, status, location and sizes.

After the preparations the fieldwork and surveys in Pekalongan started. During fieldwork the GPS-application my maps was used to locate the measurement. Photos and filling in the surveys as made before from Google Forms were done on sight. The fieldwork was done by scooter with the measurement equipment such as measuring tape, telephones and divers. The specifically used divers were two DI501-10m divers and one CTD-Diver 50mm which also had the possibility to measure salinity, all of them from Eijkelkamp SWS technology. The divers were used to measure water level differences between the river or canal and the inundated area, figure 3 shows how this worked. They were placed for 24 hours at the same locations to gather information about water level differences. This data later was processed and information about the possibilities of drainage using gravity was concluded. All the collected data later was processed through Excel, ArcGIS and Google Earth. The information from the survey was combined with the specific coordinates and photos were added. This led to an Excel with all information of the water infrastructures and waterways. All the Excel data was implemented into ArcGIS and Google Earth to create maps.

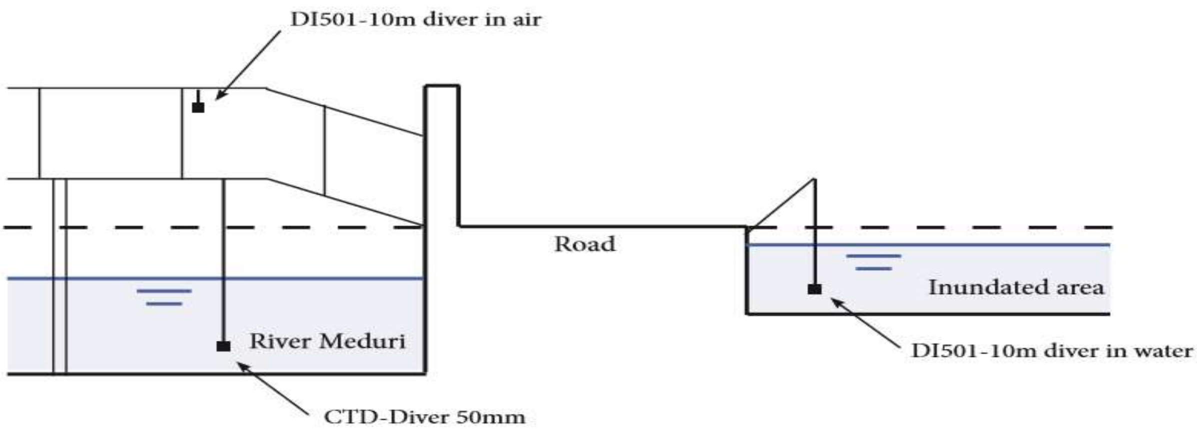

Figure 3 Schematic illustration of diver placement.

Besides the fieldwork there were 55 interviews with governmental and local stakeholders in kota and kabupaten Pekalongan. Such as Public Works who works on, road access, building residents, urban planning projects and water management (Ismanto & Niftah, 2016). Furthermore with PSDA which only focusses on water management tasks (Antayo & Prawukanto, 2016). And with BAPPEDA which is an umbrella organization that communicates with the province and does the planning and managing the finances of all other departments (Rumingsih, Wisnugroho, & Anita, 2016). At last interviews with the local people were done to gather information about the floods and where these floods occur. Most of the interviews were done with Amalia Rosaline who translated Bahasa Indonesia to English.

Results

The researched area could be divided into four different drainage areas with each its own sub systems, shown in figure 4. Raised roads and water ways were used as borders. The divers measured a water level difference between river Meduri and sub system 1.1, 1.2, 2.2 and the fishponds northern of 4.1. In sub system 3.3 a water level with canal Bremi was measured. The diver data showed that the water level of the Meduri and Bremi is lower at certain moments than the water level in the inundated areas. This suggests that draining using gravity is possible. A first calculation showed that the water level is able to drop variating from 7 centimetres in sub system 2.3 to 23 centimetres in sub system 1.2. It is still unclear how much surface will become dry using drainage by gravity because height data was not used during this research. The processed diver data can be found in appendix 1. Both river Meduri and canal Bremi are influenced by the tide of the Java sea, with high tide water from sea flows into the water ways. Therefore the water level raises in the waterways. Sub system 1.1 is already draining water to river Meduri. This happens during the day when it is low tide which causes the river to be low, during the night the water level raises and the intakes are closed to prevent water from flowing in.

By doing more than 92 measurements on waterways and water infrastructures, it became clear that there are several fatal locations. At these locations water from the Meduri and Bremi intrude into the rural and urban area, figure 4 shows these locations with red dots. The connections are mostly culverts but also several bridges which allowed water to intrude into the rural or urban area causing diurnal inundation, examples of these connections are shown in figure 5 and 6.

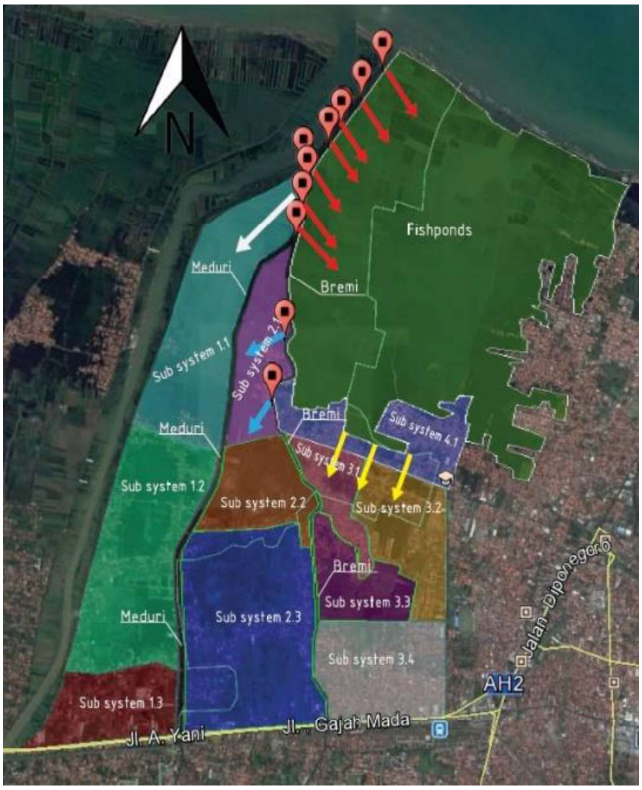

Figure 4 Locations indicated with red dots as found during field research where water can intrude.

Figure 5 One of many culverts which allow water to flow in to the rural or urban area.

Figure 6 A bridge which allows water to flow into the fishponds.

There are in total four different stakeholders who focus on the water management of the area. These stakeholders are, DPU, PSDA, BAPPEDA and the province of Central Java. The organizations occur as well in kota as in kabupaten, except for PSDA because kota does not have such organization. There are several plans in progress, such as investing in upgrading poor neighborhoods, a levee in Bandengan and improving the drainage system. Furthermore many small pumps are installed but without any communication of location and capacity. There are also two future plans that do cross the administrational border, but these plans are not yet executed and a masterplan was not available. The cooperation between the stakeholders is not always good. The organizations have a shortage on budget and are only making plans within their administrational borders, except when there is help from the central government. Furthermore kota and kabupaten Pekalongan are financed separately and are not yet willing to share their budget outside their own borders.

Conclusion

The measured water level differences as measured on the five measurement locations suggests that draining water using gravity is still possible between the inundated area and the river or canal. This will reduce the water level in the inundated areas. But not all water can be drained because the measurements showed that in some areas the water level in the inundated areas is always lower than the water level in the river. At these locations pumps will still be needed to drain water.

Connections between river and land or fishponds, such as bridges, culverts and intakes are negatively influenced by bad maintenance. The badly maintained water infrastructures and openings allow water to flow in and cause inundation. To stop water from flowing in these openings should be closed in a certain way, but this brings the problems that the fishponds will not be able to receive the fresh water as needed to grow their fish.

Kota and kabupaten both have their own plans to solve the inundation issue, but most plans do not cross their administrational border. This is a problem in solving the inundations, because water from one area flows in another. Therefore cooperation between the areas is needed to solve the inundation problem.

Discussion

There only were five measurements focussing on the possibilities to drain water using gravity. These measurements were only done for 24 hours, to get more exact data about the possibilities to drain water more and longer measurements need to be done. Furthermore height data such as Digital Elevation model or GIS should be used to gather information about which are the lowest and most critical points, this may lead to a further dividing of the sub systems. If the needed information is present, these areas could be modelled. This will give more insight about how much the water level will exactly drop in the area and which surfaces will become flood free.

The real solution to solve the inundation problem is to start a good cooperation between kota and kabupaten Pekalongan. If the stakeholders in these areas are willing to work together more budget and knowledge will be available. They have to see the problem locations as one to create a long term strategy to solve the inundation problems. It would be an idea that water managers from stakeholders of kota and kabupaten create a team that focuses on solving the inundation problems.

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Appendix 1 Diver data processed and location measurements

Point 1	Answer
Information	Fishponds could drain to river Meduri
Salt water measured in Meduri?	Yes
Location	Fishpond to Meduri
Is drainage using gravity possible?	Yes
Indication of the maximum difference in water level in cm	20
Indication of the duration of possibility using gravity drainage	10 hours
Indication of the time of drainage using gravity	05:00 - 14:00
Current water infrastructures	Not available
Urban or rural area	Rural
Surface which could be drained in m² (sub system 2.2)	375923
Total amount water could be drained using gravity m³	75184,6

Point 4	Answer
Information	Fishponds could drain to river Meduri
Salt water measured in Meduri?	Yes, same measurement as point 1
Location	Fishpond to Meduri
Is drainage using gravity possible?	Yes
Indication of the maximum difference in water level in cm	15
Indication of the duration of possibility using gravity drainage	4,5 hours
Indication of the time of drainage using gravity	05:00 - 14:00
Current water infrastructures	2 intakes which are used to drain water
Urban or rural area	Rural
Surface which could be drained in m² (sub system 1.1)	881563
Total amount water could be drained using gravity m³	132234,45

Point 5	Answer
Information	Fishponds could drain to canal Bremi
Salt water measured in Bremi?	Yes
Location	Fishponds to Bremi
Is drainage using gravity possible?	Yes
Indication of the maximum difference in water level in cm	21
Indication of the duration of possibility using gravity drainage	24 hours
Indication of the time of drainage using gravity	Always
Current water infrastructures	Not available
Urban or rural area	Rural/urban
Surface which could be drained in m² (sub system fishponds)	3991067
Total amount water could be drained using gravity m³	838124,07

Point 2	Answer
Information	Canal Ca_11 could drain to canal Bremi
Salt water measured in Bremi?	No
Location	Ca_11 to Bremi
Is drainage using gravity possible?	Yes
Indication of the maximum difference in water level in cm	7
Indication of the duration of possibility using gravity drainage	7 hours
Indication of the time of drainage using gravity	3:30-11:00
Current water infrastructures	Pumping station and intakes
Urban or rural area	Urban
Surface which could be drained in m² (sub system 3.3)	309450
Total amount water could be drained using gravity m³	21661,5

Point 3	Answer
Information	Fishponds could drain to river Meduri
Salt water measured in fishponds?	Yes
Location	Fishpond to Meduri
Is drainage using gravity possible?	Yes
Indication of the maximum difference in water level in cm	23
Indication of the duration of possibility using gravity drainage	14 hours
Indication of the time of drainage using gravity	04:00-20:00
Current water infrastructures	Not available
Urban or rural area	Urban
Surface which could be drained in m² (sub system 1.2)	995381
Total amount water could be drained using gravity m³	228937,63