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Preserving the Veins of the Urban Society, an insight in the stakes, stakeholders and smart solutions

The relevance of the Smart City Concept in planning waste water management

Bachelor Thesis

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Preface

In front of you lies the thesis 'Preserving the Veins of Urban Society'. The research is conducted, through various interviews with experts and people with experience concerning the topic. The thesis is written in the context of finishing my bachelor of Geography, Spatial Planning and Environment at the Radboud University Nijmegen. I have been preoccupied with researching and writing the thesis since March, 2020 until the end of June, 2020.

In collaboration with my thesis mentor, Lothar Smith, we have come to a feasible research topic and question. The research could be defined as a qualitative study and using mostly interviews and literature studies, a conclusion regarding the research question has been reached. The research was supposed to take place in Yogyakarta, Indonesia. Unfortunately, because of the travel restrictions set, due to Covid-19, the fieldwork in Indonesia was not possible. Therefore, the writing and research have taken place in the Netherlands, although it was still focused on Yogyakarta, Indonesia. The reason I preferred conducting research in Indonesia instead of the Netherlands is because I am very much interested in the state of affairs in other countries. Especially countries in different continents. The chance to do research in and about Indonesia was a chance I could not pass.

Next, I want to thank various people for the help with my research. Firstly I want to thank all of the respondents who were most helpful and sympathetic in providing all the help. Not only did they help in the form of an interview, but they also gave me suggestions and comments on how to expand the research further. Secondly, I want to thank Utia Suarma of the Faculty of Geography Universitas Gadjah Mada and the student Novanda Nurul. Both of them have helped me contact some much needed contacts, which I could not have accomplished without them. Another important thank I feel like has to be made, is to my fellow bachelor-writing colleagues. They have helped me in my hours of need, when I did not know how to proceed. Also some of them have made the effort to read my thesis and give helpful feedback. And lastly I would like to thank my supervisor Lothar Smith, for both helping me when I was stuck, but also inspiring me during the research subject development. Next to this, he gave me helpful feedback and comments on how to improve the thesis. I very much hope it will be a pleasure to read.

Summary

The Global water problematic is one of the most attention deserving issues in the world at the moment. Around 2 billion people, at this time, do not have access to clean water and Indonesia is one of the 50 countries with the least clean water availability. Mostly the poor part of the population struggles with this problem, given that the richest part of the civilization has proper access. Next to the poor access to clean water, a lot of people do not have access to sanitation, which contaminates the water even further. Several Sustainable Development Goals are appointed to Indonesia concerning water, sanitation and reducing water pollution. Considering people need to act differently in order to improve the water quality, the Smart City Concept might offer a solution. The global urbanisation is the major problem for water contamination, because it endangers water availability. And next to that, a lot of people do not own the knowledge of how to properly dispose waste, which leads to people disposing in rivers and nature. This water contamination has several consequences, for instance the impact on nature. Fishing and agricultural activities could become more difficult to undertake. Also several diseases have been connected with the water quality. Colorectal cancer has been connected with the presence of nitrate in the water and diarrhoeal diseases are common in Indonesia, because people often defecate in the water. As an alternative for the surface water, ground water gets pumped up, this leads firstly to contamination of the aquifer water and secondly to land subsidence.

The goal of the research is to give an insight in the water pollution in Yogyakarta, including the causes and consequences, in order to research to what extent the Smart City Concept could mitigate the causes of urban river water pollution. This goal should provide a conclusion to the research question, which is the following: How could water pollution in agglomeration Yogyakarta be mitigated using the Smart City Concept? This question is answered using different sub questions, all focused on a particular subject. Respectively the causes of urban water pollution, the consequences of this, the stakeholders in the issue, current and former initiatives and the implementation of the Smart City. The research is relevant on both a societal as a scientific level. It is scientifically relevant, because there is little research of the Smart City Concept on waste water management, even though it is a potentially relevant initiative. Next, it is relevant on a societal level, because the absence of water pollution is very good for the society. If there is less or no water pollution, it means public health increases and a better public health has various positive effects on the society.

The issue researched is approached using various theories, among which the Layers Theory, the Waste Hierarchy and the Theory of Bourdieu. These theories are used to place the subject within a framework, to look at the issue from different perspectives. Furthermore, in the Theory chapter various concepts regarding water pollution in Indonesia and the implementation of the Smart City Framework are discussed. For instance consequences regarding the polluted water in Indonesia. For example, the contaminated water influences public health. People could get sick, even fatally, by certain compositions in the water. Harmful substances like nitrate or E.Coli could lead to diseases, which affect child growth and child mortality. These harmful substances infiltrate the water mostly through bad water use. For instance by overusesing fertilizer and pesticides, or by open defecation. Simply put, if there is more education, in order to raise knowledge and awareness concerning the topic, the situation might improve. Next to the increasing awareness, there are several initiatives. Initiatives like communities that share and develop water systems, or building latrines. Although another way of implementing initiatives is using the Smart City Concept, which focuses on achieving a sustainable and efficient city, using technological developments and ICT developments. The Smart City Concept is expensive, luckily the region of Yogyakarta is a fairly strong economic region, which makes it a feasible city for the Smart City Concept. The research focuses on mitigating causes rather

than adapting to the consequences. There are some mitigating alternatives available, for instance smart garbage management, reusing components of the waste water, waste water monitoring or a city wide smart water management system.

The research aims to find a relation, to what extent the Smart City could mitigate the causes of river water pollution in Yogyakarta, in order to experience less effects of the consequences. This will be examined through a case study, it will be conducted on a qualitative manner using interviews and a broad literature study. Several people are interviewed, some especially for their expertise, but also some more explicitly for their opinion.

The first cause discussed in the results section is the presence of septic tanks. Normally septic tanks are used to clean the waste water containing mainly excrement, however in Indonesia maintenance is not a regular occupation. Therefore the tanks do not work as they are supposed to. This absence of maintenance of septic tanks, introduces the next cause. This cause discusses the maintenance into deeper detail. The absence of maintenance of septic tanks is not the only absence of maintenance of resources. The pipes and treatment plants are also not cleaned often. These resources are privately owned, which means these companies want and need to make money. That is why they do not invest in maintenance and development, it will cost a lot of money, but at the same time it will not produce a lot of revenues. Next, another cause for water pollution is the governmental situation. A big project, like a complete sanitation system renewal, is not realistic in Indonesia, even if it was physically possible. Due to 'political scheming' every big project of a government, will be terminated by the next leading government. This makes big investments hard to implement. The consequences of river contamination influence people, in the form of diseases, but also in physical and economic ways. Firstly, because excrement has infiltrated the water, it contains diarrhoeal bacteria. If people consume the water, they might get sick. Sicknesses like E. Coli could have fatal effects, especially on children. These diseases also influence the growth of children with the additional consequences coming with growth stunting. Next, physical consequences could occur due to bad water quality. As an alternative for the contaminated surface water from rivers, people pump water from the ground. This could result in land subsidence, what could have hazardous effects if the city sinks too deep. The last important consequence is an economical aspect. If companies have to improve the treatments and such, the costs are high. These high prices for development are diffused amongst consumers to afford the investment. This leads to higher prices for water, which leads to more water inequality.

Next, stakeholders related to the urban river pollution are discussed. Firstly the unclear ownership issues of water resources are discussed using the Layers Theory. This theory distinguishes various layers, to visualise the interrelations of the layers. The first stakeholders distinguished are the inhabitants. Inhabitants could on the one hand contribute, by organizing initiatives, but on the other hand participate in polluting the water further. The government is a stakeholder as well, because they could, like the inhabitants, set up initiatives. However, the government could incense other parties to behave in a proper manner in order to reduce their irresponsible disposal or water usage behaviour. Another party able to start initiatives and contribute to raising awareness and knowledge are universities. The Gadjah Mada University could help in developing a Smart City, partly by developing initiatives and otherwise by innovating helpful technologies and educating. The last stakeholders distinguished are organisations. Organisations like the World Bank could contribute to improving the water quality by for instance investing in community work or set up interventions themselves.

The next part of the research focuses on the current initiatives present in Yogyakarta or in similar cities. Firstly, waste water has various components that are reusable. And a lot of these reusable components could be extracted. Examples of reusable components in the water are plastics,

phosphor and sulphur. The downside of extracting these components, is the fact that improving a plant to make it able to extract these components, is most expensive and requires maintenance. Another initiative is the Cap and Trade market. This is a market system aiming to reduce the total pollution of the water by creating a market in pollution rights, aiming to trade rights in order not to exceed the maximum pollution. The revenues made by this market, can subsequently be used to improve water systems. Next to this fairly top-down approach, bottom-up approaches are relevant in Indonesia, considering bottom-up has proven successful in the past. Several bottom-up approaches are applied already, like STBM. This is a program mostly focusing on triggering people to behave in a more responsible way in order to decrease the occurrence of diarrhoeal diseases and environmental impacts. Similar bottom-up approaches are implemented by the World Bank, mostly focusing on separating the solid waste from the river. These approaches also have a positive effect on the job market, given that jobs are created. Next, an initiative regarding supplying insight in the water quality is important. If there is viable data concerning the quality on various locations, the contamination could be opposed at the core.

The final result chapter discusses the implementation of the Smart City Concept. Considering the previously discussed stakeholders and initiatives, various initiatives compatible with the Smart City have been selected and elaborated. Firstly Smart Monitoring and Smart Leakage Systems, this is an initiative applicable in several ways. It mostly focuses on providing data to subsequently be able to locate the big polluters or defects in the water systems. The next initiative disputes the reusage of components in the water. Various initiatives, like smart collection routing systems or community waste collection could result in the separation of reusable components, like plastics, which thereafter could be recycled. Thirdly, the emphasize that education, knowledge and awareness are very relevant concerning het development of a Smart City. Smart Cities are meant to provide a high capacity for learning and education. Given the fact Yogyakarta has a University, it has people who could lead and develop the Smart City. Next to the educating of people to develop the Smart City, this education has to improve the knowledge of society so they use their waste properly. The best way of using waste is preventing to create waste according to the Waste Hierarchy. Therefore this is the ultimate goal.

Lastly the Application of Smart Systems in Yogyakarta is discussed. Mostly focusing on whether or not previously stated initiatives are realistic and possible in Yogyakarta. The essence of most Smart initiatives are dependent on ICT resolutions. The monitoring and maintenance of sanitary resources could be done more efficiently, considering the ICT sources indicate when and where maintenance is required. This implementation creates jobs in maintenance and the ICT sector for monitoring. To successfully implement such initiatives collaboration of the government, the private sector and the university is needed. So there is an executive, wealthy and innovative power in the project development. It is necessary to not implement all initiatives on a city-wide scale in the first place. It is important to first create awareness amongst the people so they can ‘create’ demand for clean water.

Considering the previously discussed affairs, the research question will be attempted to be answered. According to the research conducted, the Smart City would in theory be a potentially relevant approach in order to mitigate the causes of urban river water pollution. However, in practices the implementation is not as black and white. It is very expensive and it is not clear all parties are willing to cooperate. Therefore the Smart City should start through a bottom-up approach, in order to firstly raise awareness and create knowledge. This way more small-scale initiatives are initiated and these small-scale initiatives could be supported by the university, government and other organisations like the World Bank.

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1. Introduction

"Clean accessible water for all is an essential part of the world we want to live in and there is sufficient fresh water on the planet to achieve this. However, due to bad economics or poor infrastructure, millions of people including children die every year from diseases associated with inadequate water supply, sanitation and hygiene" (United Nations, 2019).

According to a report of the World Health Organization in 2017, the global water problematic is one that deserves attention of the world. Because at this time, still around 2.1 billion people do not have access to clean, uncontaminated water (WHO, 2017). In this report information about drinking water availability, sanitation and hygiene is discussed. The basic water availability in Indonesia is among the 50 countries with the least water availability. For the richest part of the population the availability is fairly high, towards 100%. For the poorest part of the population the access to basic drinking water is around 60%. These numbers are quite comparable with the basic sanitation in the country, but these are a little more extreme. The richest part of the population has yet again around 100% availability to sanitation. The poorest part of the Indonesian people on the other hand have merely 30% accessibility to the basic sanitation (WHO, 2017). This results in people having to defecate in the water or in nature (Suprayogi et al., 2019). This bad way of disposing defecation has consequences, on environmental and social levels. These consequences will be discussed in the theoretical and empirical chapters.

The improvement of the water quality and sanitation in Indonesia is not only needed, because the inhabitants need it, but these two subjects are also elements of the Sustainable development goals, namely SDG 6.1, 6.2 and 6.3, are focussed on respectively water, sanitation and reducing water pollution (United Nations, 2019). The first two SDG's are more focussed on giving people the services they need. However, the third one, reducing water pollution, is more complicated, because it focusses on sensible usage of water in the sense of recycling and reusage. That means that people have to use the water smarter. This introduces the base of the perspective of the research, namely through a Smart City Concept lens. The Smart City could introduce the knowledge and awareness needed to treat and use the water in a more sensible way. The problems don not have a clear solution to just adapt to the bad water, that is why the problems should not be adapted to, but mitigated to. That means looking at the causes and try to withhold these causes from 'happening'.

1.1 Problem definition

The occurrence of water pollution is possible in different ways, there is a distinction between type of pollution, the concerning prevalence and the factor that caused the regarding pollution. One of the major factors responsible for water pollution is the growing population. This is not a direct cause, but an indirect driver for the direct causes (König et al., 2010). The growing of urban areas is to be defined as a population growth and the extent of urban areas, for instance through immigration from rural areas to urban areas or simply natural increase of population (Open University, 2016). The increasing population pressure threatens the (clean) water availability, mostly because the already stretched water and sanitation resources cannot cope with the increasing pressure (Open University, 2016).

In Indonesia the knowledge about proper use of water is limited, therefore people are a big cause of the pollution. Another reason for the pollution of water is because a lot of people living at the shorelines of the river dispose their waste by simply throwing it in the river, for instance the Kali Code river in Yogyakarta (Suprayogi et al., 2019). The reason for the inhabitants of Yogyakarta to pollute the river is, according to the literature, because there is little education concerning valid disposal of waste, but also bad sanitation and sewage (Coowanitwong, 2006). A big part of the pollution problem is domestic waste that makes fishing and agricultural activities questionable (Suprayogi et al., 2019). Next, nitrate in the drinking water could cause Colorectal Cancer, and it is proven there is a significant correlation between the presence of nitrate and the incidence of Colorectal Cancer amongst local populations consuming this water(Fathmawati et al., 2017). Another big part of the pollution of the water is the open defecation in Indonesia, which happens to this very day. It has become a culture or habit to defecate in ponds or rivers, because daily food needs are prioritized compared to building latrines or toilets (Meliyanti et al., 2019). This could increase the presence of diarrhoeal diseases, because faeces in the water, contaminate the water with diarrhoeal diseases. Which firstly leads to higher child mortality and secondly to child growth stunting (Radar Jogja, 2018). An alternative for water collecting is the use of aquifers. People use aquifers, because they are not as contaminated as the surface water. Aquifers are ‘storehouses’ of sorts for water, it is a water containing and transporting layer in the ground. They can be used to drain water from (USGS, n.d.).There are 2 big aquifers near Yogyakarta, the Water and the Beach Ridges aquifer and Sand Dunes aquifer (Thin et al., 2017). If those aquifers are drained too much, the polluted water could infiltrate the ‘clean’ aquifers (USGS, n.d.). Also, if the aquifers are drained too much, salt water coming from the sea could infiltrate the aquifer as well. This firstly causes salinization of the water and secondly could change the hydro chemical processes of the ground water (Thin et al., 2017). In other words, if the aquifers are to be misused, it will pollute the water even more. Next to that, draining aquifers could lead to land subsidence, what could have hazardous consequences in coastal areas (Abidin, 2011).

1.2 Goal of the research

The goal of the research is to provide an insight in the problem of the high pollution of the water in Yogyakarta, to thereby be able to give insight in possible ways to mitigate this particular problem by using the Smart City Concept. Yogyakarta is experiencing urbanisation and the problems coming with it. This is a global phenomenon and therefore this study will be a case study to attempt to construct an analysis to have a clearer view on the problems and the possible solutions to tackle it. So other regions like Yogyakarta might encounter or currently face comparable problems coming with urbanization. If this case gives insight in mitigating the problem in this particular situation, it in turn gives other regions the opportunity to mitigate in a similar way. Thus the goal of the research could be formulated as: The research intends to give an insight in the water pollution in Yogyakarta, including the causes and consequences, in order to research to what extent the Smart City Concept could mitigate the causes. This goal is to be formulated as the following research question.

1.3 Research question:

How could water pollution in agglomeration Yogyakarta be mitigated using the Smart City Concept?

In order to answer the main question, various sub questions are formulated and answered. Each sub question focuses on a particular subject, some more important for the answering of the research question than other. The questions less focused on answering the main question are aimed at setting the scene of the research.

1.4 Sub questions:

1.4.1 What are the causes of the pollution of the rivers in Yogyakarta?

The causes form the base of the research, because the research focusses on the mitigating of the water pollution. In order to mitigate a cause, you must know the cause. If the causes are clear, information could be extracted, whether from a literature study, or interviews.

1.4.2 What are the main consequences of pollution of the rivers in Yogyakarta?

The problem to be ‘solved’ needs to be clearly defined why the particular problem is a problem. To determine this, the consequences need to be clear. If the consequences are minor, the problem might not have priority to be solved.

1.4.3 Which actors are stakeholders in the problem?

Water, if it is ground water or surface water is a public good. Everyone has the same right to it and everyone is able to use it. The question in this case is by whom and how is it used by the various users, or stakeholders. If the stakeholders are clear, It is also important to keep the causal processes of people’s actions and watch the differences in problem definition of different people.

1.4.4 Are there possibilities or initiatives to reduce or reuse the content of the waste water in Yogyakarta?

A way to nudge people into using proper sanitation, might lay with the idea of not punishing the bad cases, but reward the right use. So it might be a possibility to find an alternative for the current disposal of excrement (and waste). One of the major sustainable processes, also often combined with the Smart City Concept, is a circular process. If the waste and defecation could be stored in some way and delivered, maybe there could be a reward for it. And next to that it is important to look at interventions and initiatives implemented already in different and similar cases to gain insight in the possibilities.

1.4.5 How could the Smart City Concept be implemented in mitigation in the water management?

The Smart City Concept is an important concept within the research, mostly because it is a sustainable way to innovate a society and economy. Using the Smart City Concept, education is crucial, to impose awareness, so the municipal knowledge is better, and less problems occur.

1.5 Scientific Relevance

In the last 50 years the world population has more than doubled, since in 2012 the world population exceeded the 7 billion people. The population is still growing and it comes with externalities, externalities that threaten natural dynamics, resource availability and environmental quality (McGrane, 2016). Many countries in Africa, South America and Asia still note a fast increasing urban population growth. This growth exists of both natural growth and migration to the cities (Open University, 2016). The growth in population often leads to decreased air and water quality (Duh, 2008). This is the case in Yogyakarta as well. This water quality degradation, which this research will be focussed on, has numerous consequences. For example diseases, bad water for rural practices and bad fishing conditions (Duh, 2008). Several researches have been done on smart water management focussed on various cases. Also research focussed on waste water had been done. Although there is little research about how a revolutionary approach such as the Smart City could be of use in waste water problematic. The Smart City approach is a potentially relevant approach, because the Smart City could improve various processes, by tackling complex interrelations between stakeholders. It adds conceptual value, because it gives insight in how to enhance a system in order to tackle the issues in an efficient and sustainable way (Enel, 2018). This research focusses for a considerable part on why people dispose their waste, solid or excrement. With a focus on a solution which mitigates the causes of the behaviour of inhabitants of defecating in the water.

1.6 Societal Relevance

The research is relevant on a societal level, because the stakeholders are of great importance in the context of the issue, whether they add to the causes or they are struck by the consequences. This means the actors are stakeholders in the subject. According to Coowanitwong (2006) a big part of the (mostly poor) people living along the riverside get rid

of their waste(water) by disposing it in the river. Besides that, the same people experience the negative consequences of this irresponsible disposal. The biggest cause of child mortality in Indonesia is diarrhoeal diseases, coming from the wells (Unicef, n.d.). People are not only part of the cause and the victims of the consequences, given that they can be actively involved in the solution. Because community organization could form one of the fundaments of tackling the problem of the contaminated water (Coowanitwong, 2006). Another way to tackle the problem of water pollution in urban rivers in Indonesia could be more towards the IT solution, with the Smart City Concept. The Smart City Concept could be implemented on water management, as well as on other cases, like infrastructure or money transactions (Hamilton, 2017). For water management it could be used to monitor the water, so there is more information available about the water quality. (Logicladder, 2017). Another implementation of the Smart City in water management might be to educate and create awareness (Duh, 2008).

2. Theoretical explorations: Urban livelihoods, behaviour and river quality

The problem focussed on in this research is not coming from one single cause. It is divided over different causes, caused by different actors. For example the people, the government and the environment. These actors act like the way they do, because of the mental structures developed over time. People with a similar social environment, frequently develop similar structures, which leads to them creating a similar mental structure (Bourdieu, 1990). In regard to the research, people who dispose their waste improper are often people with a similar environment (Suprayogi et al., 2019). If these people are to be influenced by other structures, their behaviour might change. In this case the resource water, or preferably water quality is at stake in the issue. The improvement of water quality is possible, through developing a proper water system, containing good sewage pipes and working water treatment plants. Also, if people use water in a responsible way, the water quality will not contaminate further. Responsible use of water could be defined at proper disposal of waste and defecation, good land use and not overusing water. The formerly stated uses of water are connected to various societal factors, such as economic and knowledge. Economic because the development of water systems, costs a lot of money and knowledge, because people should know how to use water responsibly. This is in line with the capitals, discussed by Bourdieu.

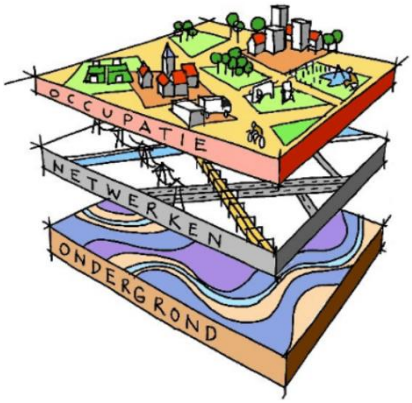
Bourdieu assumes there are different kinds of capital, which affect the concerning resources. In this case the resource is the water quality and the capital is to be divided in the different capitals described by Bourdieu. The capitals used in the research are Economic Capital, Social Capital and Cultural Capital. Explained shortly respectively money, social connections and ‘knowledge of legitimate culture’ (Bourdieu, 1990). Another reason for the compatibility of Bourdieu’s theory in relation to the research is the other three key concepts of the theory, Habitus, Practices and Fields. Habitus describes the characteristic way of actions of people within a specific group, but also the way of thinking, feeling and acting. In the research one of the causes of the bad water quality is people who dispose of waste and defecation in the water or other ‘bad’ places. This behaviour has reasons and these reasons are to be affected by social conditions for instance. Next, the Fields. The Field could be explained as a game, but a game with several realities. Everyone experiences the game differently, people ‘play’ the game in their own particular social context. The game could be identified as the habit of disposing waste in a bad manner. The social context in this case could be as it is because there is invalid economic capital or social capital, simply put there is no education concerning disposing on a valid matter.

Furthermore, various factors influence the manner and reason of improper use of water. These factors are all related on a certain level. To be able to ‘read’ the physical structure of the city and perceive the interrelations between the physical characteristics of a city. Dirk Sijmons, a Dutch urban planner, created the Layers Theory (Figure 1) in order to do this (Hospers et al., 2015). He distinguished a city into three layers, namely the Green-Blue Layer,

the Network Layer and the Occupational Layer. Respectively they represent the ‘soil, subsoil and water systems’, ‘infrastructure (roads, canals, public transport, cables and pipes) and lastly the dynamic layer for real estate and location development (Hospers et al., 2015). These three layers are supposed to be in balance. This means if a location development takes place on the occupational layer, it is very important how this development affects the other layers. This theory is relevant regarding this research, and the stakeholders, because in an urban context the ownership of natural resources are less clear. The Layers Theory is also important for this research, because the model is a representation of the concerning problem.

Figure 1

Layers Theory



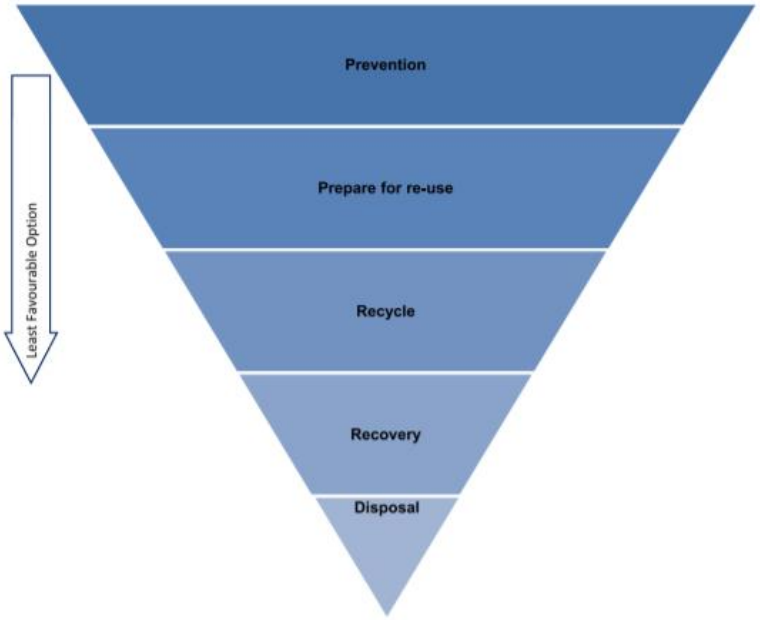
Source: ruimtexmilieu.nl
Occupatie (1) : Occupational Layer
Netwerken (2): Network Layer
Ondergrond (3): Green-Blue Layer

The Occupational Layer is experiencing major development, urbanisation. This affects the other layers, because these layers do not grow as fast (Hospers et al., 2015). According to Sijmons before an implementation or project is initiated, a metaphorical skewer has to puncture all layers. Doing this shows how the various layers influence each other. This could be an asset for the planning process of Yogyakarta in order to make sustainable choices.

Figure 2

Waste Hierarchy Theory

Source: Papargyropoulou et al., (2014)



The waste Hierarchy Theory (Figure 2) is a theory about the most favourable manner of dealing with waste. The lower on the 'upside-down' pyramid, the least favourable, because it is the least sustainable way of using waste (Papargyropoulou et al., 2014). According to the waste hierarchy, the least favourable way of using waste is simply disposing it. The reason this is least favourable, is because disposal costs and the exclusion of the possibility to reuse it. Secondly recovery, the waste is recovered as a different resource, for instance processed into biofuel. Next, recycling waste is better than previously stated actions, because less resources are lost in the process. Fourth, reusing the waste. Reusage is often explained as the goal to keep and care about things, for instance by repairing them or finding a new use for them (Gregson et al., 2014). Lastly the most favourable option, prevention (Papargyropoulou et al.,, 2014). Prevention is perfectly applicable for the research, given the research focuses on mitigating the causes of pollution.

An important definition in this case is ‘anthropogenic’, because various causes and consequences are very much connected to this definition. According to the Merriam-Webster Dictionary (n.d.) anthropogenic is defined as:

> Relating to, or resulting from the influence of human beings on nature.

This concept is important to the research, or case, because various causes concerning water contamination are very much related to human influence.

There are three main causes explaining the quality issues of water in Yogyakarta. First, according to Coowanitwong (2006), most levels of pollution in Yogyakarta are managed fairly well. In the dense urban area of Yogyakarta, most environmental burdens are within limits, with air pollution and- solid waste not exceeding environmental hazardous levels. On the other hand water quality is a major issue. One of the reasons is because there was a garbage dump in operation until around the 1970’s (Coowanitwong, 2006). This dump is now defunct and gone, but it has contaminated the ground, which causes an ongoing contamination (Coowanitwong, 2006).

Furthermore, one of the polluting factors is the presence of nitrate, nitrate is a chemical that infiltrates the water through bad land use. The main driver of the bad land use is the increasing urbanisation. Because of the expansion of the city, farms have to move to more rural areas, to make room. In this area, the farmers neglect the soil properties. This is where the bad environmental land use begins. The nitrate itself is primarily originating from fertilizers and pesticides. And because of the distribution of water at farms, it will spread among the ground and surface water (Pacheco, 2016).

Thirdly, the water is also polluted by domestic waste. According to the City Government 82% of 145 wells are polluted with diarrhoeal diseases, especially EColi. The domestic waste comes from people who settle around the riverside, these people likely have no or bad sanitation and sewage. Therefore they drop their wastewater in the river (Coowanitwong, 2006).

UNICEF affirms this theory. According to them around 25 million people in Indonesia do not own or use toilets. Open defecation is more prevalent in rural areas, although according to the latest *Joint Monitoring Program* in 2017, around 5.6 million people in urban areas defecate in the open. This leads to them needing to defecate in nature, which can be places like rivers, forests or lakes. Next to that, a lot of people have limited service and ‘unimproved’ sanitation situations. Respectively in urban areas around 17.1 million and 5.2 million. These groups of people have a share in the open defecation as well, given the coverage of sanitation is respectively ca. 12.3 % and 3.6% (Appendix 1). These groups can contaminate the rivers, due to bad sewage or badly maintained latrines or septic tanks.

In a rural context this will not have an immense impact on water quality, but in high dense areas the environmental impact is much higher. This has a major consequence on public health, especially on child health. In fact, the biggest cause of child mortality in Indonesia is

diarrhoeal diseases. As stated by Coowanitwong (2006) there is a way to deal with the problem:

> To solve this on a simple manner: Increase community awareness of river pollution; develop individual toilets and wastewater disposals, without harming the environment; increase community organization capacity in communal sanitation building and maintenance; decrease river pollution along Code River in Inner City Yogyakarta.

This is also in line with the UNICEF report, which states there should be more education about sanitation and hand washing and next to that safer water management. In other words, the biggest challenge is to change behaviour. An opportunity to alter behaviour is nudging, which is defined as "any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives"(BMJ, 2011). Nudging does not involve changes in economic incentives, so it excludes legislation, regulation and economic interventions. An example of nudging is providing information to people in order to change their social norms, which subsequently might change their behaviour (BMJ, 2011). There are several forms of nudging, according to Sunstein (2014). He has made a list of 10 different sorts of nudges, some focused on reminding people of their actions and others that subconsciously influence people. Although not all of these nudges are relevant in Indonesian society. A few relevant nudges are for instance 'default rules', which can be defined as the possibility for people to enrol in programs, but also attention for the particular 'nudge' in education. Secondly 'increases in ease and convenience', this nudge has as goal to ease a certain action for people. For instance placing more garbage bins in the city, so people could access it easily. Next, 'warnings and reminders'. If people are reminded regularly about their behaviour, they might stop and think of their actions, resulting in people taking the time to make the 'right' decision (Sunstein, 2014).

Duh (2008) also concurs with this in a paper focusing on urbanisation and pollution. He argues that certain conditions need to be created in order to raise awareness and come up with solutions to pollution. According to Duh (2008) education is really important for decreasing domestic waste disposal. Next to that some necessities in order to realise new technologies are discussed. There has to be availability to the proper technology and the ability to actually use the technologies. So there has to be an innovating actor, like a university, to come up with the technology, but also a capable power to apply the technologies.

In Yogyakarta there are mostly community based approaches to getting access to water, for instance communities sharing springs of clean water. This is done by installing a simple water delivery system to the houses, given the springs are fairly close to the houses (Coowanitwong, 2006). "Community economic development can be seen as a centred process that blends social and economic development to foster economic, social, ecological and cultural well-being of the communities. The initial premise is that problem arising at local community level – be it in the form of poverty, job-loss, environmental degradation

and loss of community control – need to be addressed in a holistic and participatory way"(Coowanitwong, 2006).

In order to decrease the water pollution, initiatives are necessary. Although only independent initiatives might not suffice. The Smart City Concept is a concept able to tackle wider city challenges, like urban water pollution. The Smart city aims to achieve a more sustainable and efficient city, using new technological developments, among which ICT developments (Monzon, 2015). According to the research of Hamilton and Zhu (2017) about the funding and financing of Smart Cities it is very important to implement a Smart City Program in an economically growing city. Cities have to have capital in order to induce the smart city program. If a city is not financially healthy enough it might not be a good idea to try to be a smart city. Mostly the program is funded by loaning. And these loans are to be paid back by the revenues gained from economical mechanisms. In order to have growing revenues, it is profitable to make a financially growing city a smart city. When the smart city projects are realised, they will produce revenues as well to pay the loans back.

In a report of the Carepi Technical Team of Yogyakarta, the result is that Yogyakarta is a fairly strong economical region. Accompanied by the University the implementation of a smart city program is a realistic prospect. So there is in fact an innovating power and a capable power, respectively the University and the economically strong city government. The university is an important centre of education in Java, because the university has never suffered from the Independence War (Sulistiyono, 2013).

There are in fact some cases and options to mitigate and adapt to the pollution of the water supply. Some more focussed on the actual water quality but some are more focussed on improving the ability of people living near the polluted areas to dispose their waste in a proper way. For instance by making it possible to have a good working waste management system for the less wealthy neighbourhoods. According to the Smart City Platform Logicladder (2017) smart garbage management could be implemented. There are smart bins placed across the districts in a neighbourhood for instance, these bins monitor how full it is and then they will be picked up. This way there could be created a different, most efficient route for the trash cars. Sakti (2018) states that there are initiatives to reduce waste disposal, in this case solid waste, with smart routes. There are trucks driving around collecting singular bins, containing municipal waste. However this is a commercial initiative, which might have some effect on the price for the use of the bins.

Logicladder also mentions a smart wastewater management, which monitors the quantity and quality of water so there is information about the quantity and quality about the water at all time. This way less water will be wasted and it will be managed better.

An example quite similar to the Smart water management of Logicladder is provided by Yadav (2016). Discussing several cases of several cities in India, because India has, just like in Indonesia, a lot of people defecating in the water or other harmful places. In the article there is argued about a smart system to manage the water quality, mostly by monitoring it

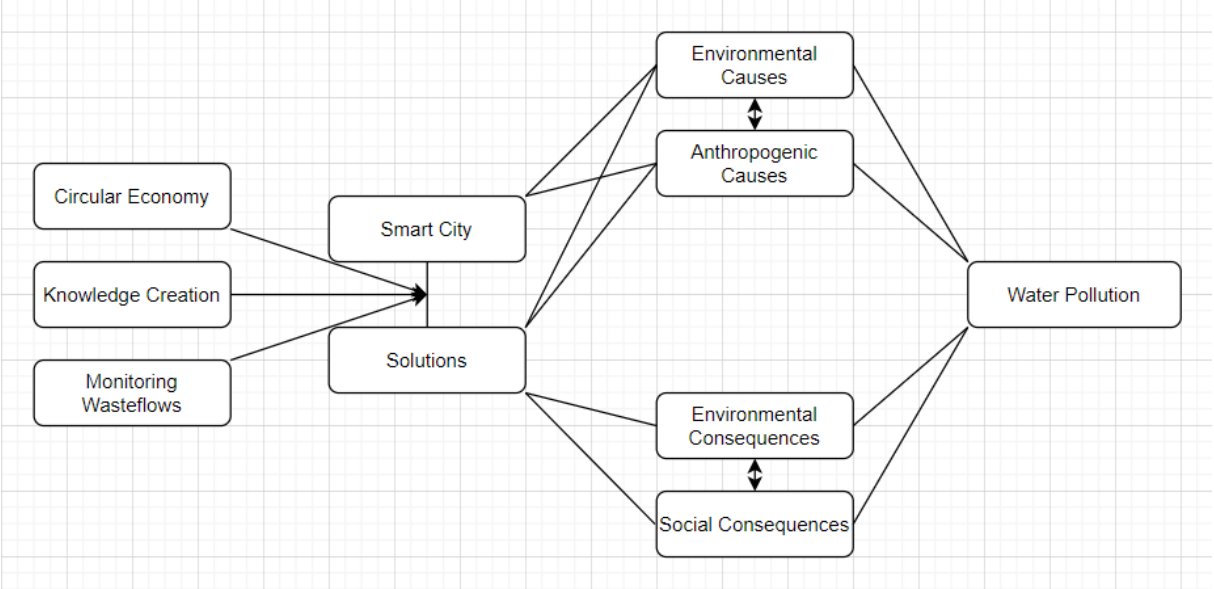
on various levels. This research is done in the 5 Indian states of Assam, Bihar, Jharkhand and Uttar Pradesh (Yadav, 2016). If you keep an interest in this framework, go see the paper *Smart Water and Wastewater Management with Smart city challenges.*

A way of implementing the Smart City Concept in Yogyakarta is trying to market the human excrement. There are particular ways in how human excrement could be reused. This has to do with the Smart City Concept, because this concept focusses on creating a sustainable, resource limiting market (Enel, 2018). There are a few options for reusing excrement. Firstly, there is a possibility to use human faeces and urine as fertiliser (Dring, 2015). But the possibilities do not cease at using the human waste as fertilizer, namely another chance for reusage of excrement is changing it in fuel. The sludge coming from the waste water is dried into biogas (Wald, 2017). Another, maybe harder to process, method of reusing human faeces is as food for animals. This animal food is made from larvae from a specific fly-species which nourishes itself with a lot of human excrement. These larvae could be used as food for animals, like in fish breeding (Wald, 2017).

2.1. Conceptual model

Following the prior elaboration on the conceptual premises of this thesis, we arrive at the following conceptual model:

Figure 3



The conceptual model for the research could be explained as a circular process. The actual start is the causes for the water pollution. For instance the bad rural land use that pollutes the water upstream, which ends up in the urban area (Pacheco, 2016). Also, the soil pollution due to an old dumping ground (Coowanitwong, 2006), and most importantly, the domestic waste and sewage product (Suprayogi et al., 2019). These causes are divided in Environmental and Anthropogenic and they influence each other as well. The real big causes are actually anthropogenic. The environmental causes are actually mostly indirect consequences of various anthropogenic causes. For instance the draining of the aquifers according to Thin et al. (2017) are partly environmental and partly anthropogenic. It is anthropogenic, because people drain it, but afterwards the composition in the ground pollutes the water further, which could be defined as an environmental process.

These causes influence the water quality, in other words, they increase water pollution. Water pollution comes with several consequences. There are several sorts of consequences. Again these consequences can be divided in two kinds of consequences, namely social and environmental consequences. In this case the diseases named above are more social consequences, because people suffer and are affected because of it. The environmental consequences are more because if the water is polluted, the ground and ecosystems get polluted as well. Firstly this is bad for the natural systems, because they get interrupted, species might become extinct and flora might not grow as it should (Suprayogi et al., 2019). The environmental and social consequences are connected as well as the causes, because they influence each other. For instance if the fish population reduces and crops don't grow

as they should, it has social consequences as well, because it could firstly result in food shortage and secondly an economic problem for the farmers (Suprayogi et al., 2019).

Of course, ill consequences like the ones named above need solutions. A lot of research is done already, concerning valid solutions to limit waste and to steer people in better disposal of waste. These solutions are a reply to the bad consequences, and are meant to adapt to the consequences. In the conceptual model there is a line between solutions and smart city. This is because the research focusses on finding a solution following the smart city concept. The Smart City focusses among other things on making a sustainable economy, for instance through implementing circular processes. So creating a circular economy. The circular economy stands for reusing resources and at the same time combining competitiveness, innovation and sustainability (Enel, 2018). Examples of possible circular markets for excrement are, as named before, as fertiliser, fuel and animal food. Other interventions that are connected with the Smart City are monitoring the waste flows. For instance the water quality and composition could be monitored, as done before in India (Yadav, 2016). Or the waste monitoring system explained by Logicladder (2017). Thirdly a possibility to improve the water quality using a Smart City lens is improving awareness and knowledge (Unicef, n.d.& Coowanitwong, 2006). Mostly through education about handwashing and sanitation. This approach is focused on preventing diseases, unfortunately it does not directly counteract other consequences, like price changes or land subsidence. In this case , the Waste Hierarchy is applicable. Through education about handwashing and sanitation, the aim is to prevent improper behaviour. Prevention is the best manner of dealing with waste, but in this case also with the spreading of diseases (Papargyropoulou et al., 2014). These three initiatives are in line with the Smart City Concept and that is why these three are placed between solutions and Smart City. These are the possible solutions that could be implemented in the case using the Smart City Concept.

Another important aspect of the conceptual model is there is a connection between the Smart City and the causes. This connection represents the possible mitigation through Smart City initiatives of the causes. This is different from the current initiatives, because the current initiatives focus on the consequences (Logicladder, 2017). The essence of this research is to study initiatives that can, using the smart city concept, mitigate the causes. That way, the problem might occur less.

3. Methodology

This chapter explains how this research is conducted. A methodological approach is needed in order to conduct a research. In this chapter the conducting of the research is discussed. The research definition, strategy and material is discussed and explained. Next, a data analysis process and reflections on my research conducting are explained.

The research is based mainly on interviews, literature. These sources are approached on a qualitative manner, because the data gained through the sources are mainly descriptive and focused on experiences and opinions. (Vennix, 2016). The base of the sources are primary sources, so directly from respondents. The base is formed mostly by studying the concerning maps and literature, which is examined further by talking to experts and other people who are acquainted with the subject or region. It is a phenomenological approach, because the people interviewed supply information containing their experiences and interpretations. These people are for instance a community head, people from the Yogyakarta City Government and people who are acquainted with the area on a different way. The various interviews are similar to a certain extent, but vary on various aspects.

3.1. Case study

This research is defined as a case study, because the research is mainly exploratory, the exact nature of the problem is defined, plus the situation is described, while testing explanations. The research matches various characteristics for a case study, according to Yin (1981). He argues a case study is needed when the following circumstances occur:

“An empirical inquiry must examine a contemporary phenomenon in its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.”(Yin, 1981)

These particular circumstances are applicable to this particular research, because the real-life context is discussed extensively. A lot of attention to the actual causes and consequences is provided, in order to elucidate the real-life context.

Given that this study focuses on the potential role of the Smart City Concept as effectuated in resolving water pollution quality issues in the Kali Code river of Yogyakarta, an in-depth case approach is required. Thereby Yogyakarta provides the contextual embedding. The study takes place in the natural context, i.e., in order to be able to generalise the study to real life situations. In the first instance this research was going to focus on the pollution of the Kali Code river in Yogyakarta, however, due to travel bans for health safety reasons because of Covid-19, it is decided to expand the orientation of this study to river pollution issues for Indonesia as a whole. Using the information gained through the research, the results will then be applied to Yogyakarta. The concerning areas researched are mostly areas situated near rivers or ponds or lakes. Therefore the research area is situated in the neighbourhoods, and possibly the less wealthy neighbourhoods, along the riverside. The area that is examined is chosen by a few factors, these factors are mostly demographic and geographic. So, it is a rather poor neighbourhood, as wealthier neighbourhoods do have

proper sanitation and sewage. The geographic necessity is that the place needs to be situated near the river, because people need to be able to easily dispose their waste in the river.

3.2. Research Strategy

This research will use several research methods, to create a 'total image'. It will consist of a literature study and interviews and for visual display a few maps and graphs are used. The reason for the choosing of three methods is to apply triangulation. The reasoning behind 'triangulation' is to use several research methods to investigate a matter. The results of the observations are related to each other. If the results point in the same direction, there could be argued the results are rather reliable. If not, there is motivation for examining the reasons for the difference in outcomes (Vennix, 2016).

3.3. Research Material

The primary source of data of the research is interviews. These interviews are done with several people, with different sort of knowledge concerning the topic. There are some respondents in the Netherlands with knowledge that could be meaningful to the research. For instance the knowledge about waste water or the management of solid waste. For the interviews in Yogyakarta, the focus is on governmental institutions and companies working on the bad water quality. The governmental agencies could give insight in previous, current and future initiatives trying to oppose the bad water quality. Other respondents for the interview are various experts on the concerning topics, preferably natives of Yogyakarta. That way the information is reliable, but with a cultural 'back-bone'. For the research it is important to speak to inhabitants of the particular area that is examined, unfortunately that is not easy to realise. Through the contact persons from Yogyakarta University several people are contacted who live in Yogyakarta to get some first-hand experiences and knowledge about the living area. The respondents were not available for an actual interview, that is why they have filled in a questionnaire (Appendix 4; Appendix 5). The Yogyakarta residents are Mbah Gondrong, a community leader of upstream Code river and an anonymous official of Yogyakarta City Government. Using the data gained through these questionnaires, primary information gained through experience and their first-hand knowledge is established (Rieh, 2002). Next, interviews to sketch a certain situation were helpful, given the fact being in the actual field has been impossible. For instance the first interview with Mitsunori Odagiri was mostly focusing on getting to know the waste systems in Indonesia and trying to sketch the situation. Because of this interview some aspects that were originally not accounted for, became important for the outcome of the research. Other interviews, with Marc Scheres, Marijn van Son and Erwin van der Krabben were more focused on getting acquainted with waste treatment systems and the circumstantial factors concerning the situation in Indonesia. Lastly Lars Tushuizen, this interview was fixed on gaining information about policies and similar situations and implementations in different countries. With this information it became clear which initiatives were more or less realistic.

The study consists not merely of interviews and the data coming from the respondents. The comments made by the respondents have been verified and expanded using literature. Also using the literature, several theories, like the Waste Hierarchy and Layers Theory are applied to the Yogyakarta situation.

3.4.Data analysis process

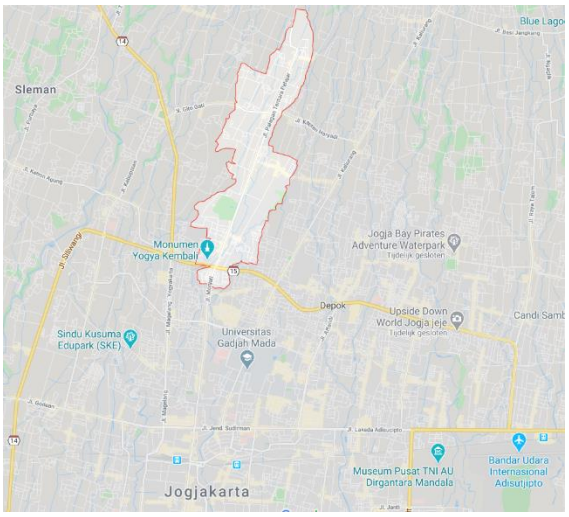
Most primary data is coming from the conducted interviews. During the interviews, I have written along with the interviews, so for every minute it was obvious which subject was discussed. The interviews conducted have been transcribed. Using these transcripts, I have extracted the valuable information from them. I have read through the transcripts and highlighted the most important parts, which is subsequently used in the Results chapter. After highlighting the important parts of the transcripts, I made a distribution of the particular citations and quotes, in order to connect them to certain sub questions. This way the quotes, citations and comments on the case could be used in the right place. Using Excel I have connected the highlighted parts to the concerning question. This way I could easily access the data necessary to answer the particular question. I have done this for every respondent independently, so I have made 5 different excel sheets for every interview, containing sub questions with the matching comments. In Appendix, an example of an excel sheet is shown

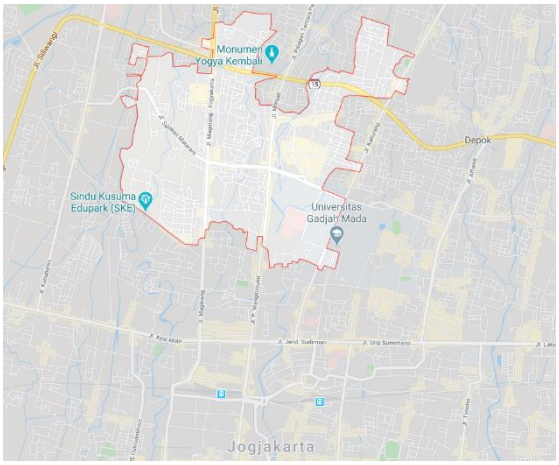
3.5. Reflections on methods and doing 'fieldwork'

In advance of the actual research, a lot of work has been done concerning the comprehensive literature study. During this study, various possible respondent came along and there were for instance different people on the Gadjah Mada University with whom I was eager to talk to. Unfortunately, a few weeks before our departure to Yogyakarta, Indonesia, the travel regulations concerning Covid-19 made it impossible for us to travel to Indonesia. This has complicated the situation of the research, mostly because in the first instance it was planned to speak to various inhabitants of Yogyakarta. Areas interesting or the research are for instance Sinduadi, Sariharjo or/and the area around Jembatan Sayidan.

Following respectively the geographic locations of the formerly stated areas (Source: Google Maps n.d.):

figure 4,5,6





The actual research would have required me to search and approach people living in these areas and ask them questions. My ultimate goal was to do brief interviews with around, if possible, 20 people. With this information, several experiences and opinions are presented. This information could have been useful in forming a conclusion, because the current conclusion does not include the opinion of inhabitants.

Another threshold regarding the conduct of research is the difficulty of contacting people for an interview. In total around 15-20 people are contacted, but getting in contact with actual inhabitants has proved very difficult. Therefore I have tried contacting people, with help of former respondents or very helpful people fro Gadjah Mada.

4. Prevention Through Intervention. Empirical Results: The context and mitigation of urban river water pollution in Yogyakarta

"I think it is striking to see nowhere in Indonesia drinking water is developed well, but literally everywhere you can buy Coca-Cola, literally everywhere" (Scheres, personal communication, May 20th 2020).

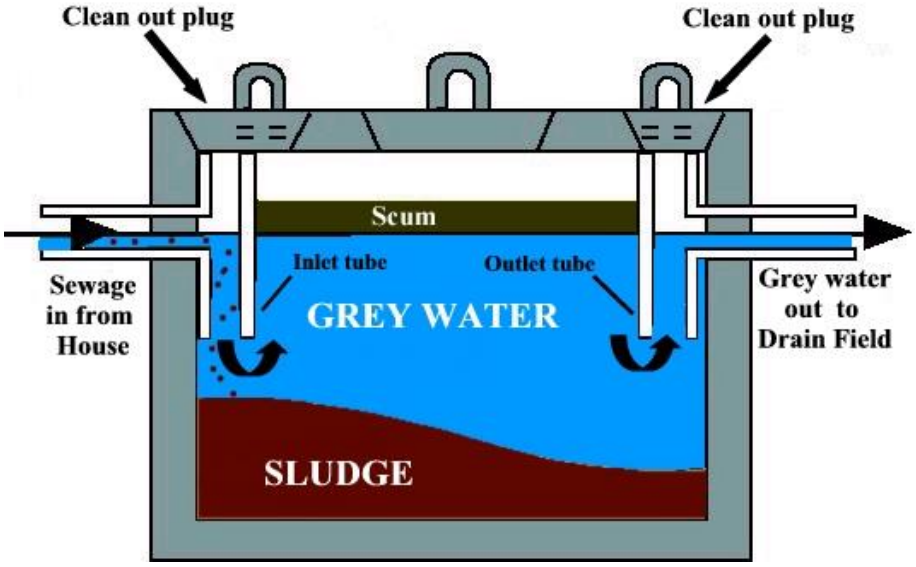
4.1. What are the causes for water pollution in Yogyakarta

The water pollution in Yogyakarta is the result of various causes, some more known than others. Causes like improper disposal are fairly obvious, although there are various causes, less known and obvious.

4.1.1. Septic tanks

The contamination of water in Yogyakarta is not merely the result of people disposing their waste and excrement in the water as suspected. In practice that is only a small piece of the actual waste disposal. In fact, Yogyakarta has almost a 100% region where the sanitary is accounted for, according to Odagiri (personal communication, May 18th 2020). Thus the problem of faecal contamination in the water is not necessarily originating from people defecating in the open water or nature. The contamination comes later on in the process of decontamination. The excrement is not sent to the sewage system where it will be cleaned and reused, like in the Netherlands for instance. Scheres (personal communication, May 20th 2020) argued in most cities in Indonesia, for instance Bandung, Jakarta and also Yogyakarta, this defecation is rather sent to a *Tangki Septik,* or a septic tank (Prihandrijanti, 2011).

Figure 7

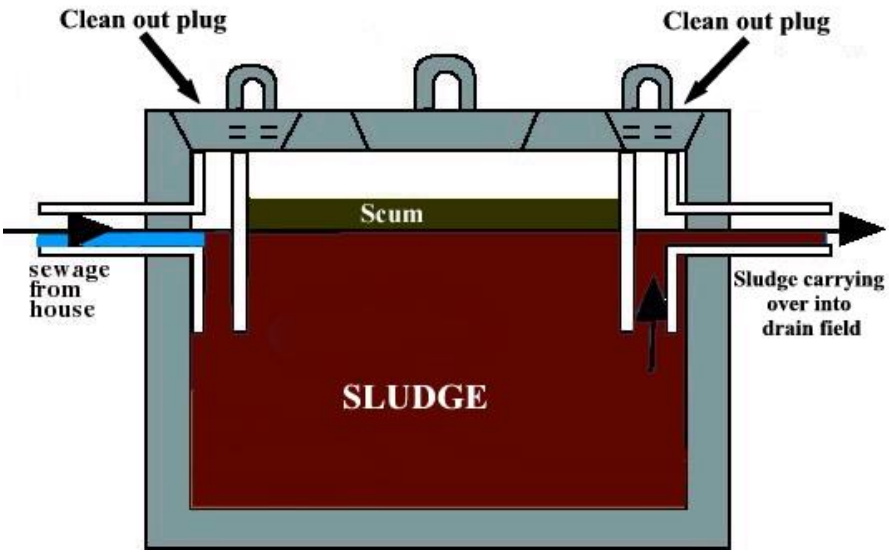


Source: Miguel, R. (n.d.). *What is a Septic Tank? What is a Cesspool? — Cesspool and Septic Pumping on the Big Island of Hawaii*. Retrieved on 23 juni 2020, van https://abccesspoolandsepticpumping.com/septic-tank-cesspool/

These septic tanks are used to decontaminate the waste water that flows in it through the use of particular kinds of bacteria. These septic tanks create some sort of sludge and this sludge is the remainder of the total waste water income. So the waste particles and solid waste is separated from the water. This sludge is the most contaminated part in the tanks and therefore the tanks have to be de-sludged on a regular basis (Scheres, personal communication, May 20th 2020). That is where the problem with the septic tanks lie in Indonesia. Firstly the structure of the tank is not operating

properly. There are tanks without lids and without a soak pit to further decontaminate the water (Prihandrijanti, 2011). Secondly there is no maintenance of the Septic Tanks, which leads to over capacitated tanks. If the tanks are not de-sludged on a regular basis, the load of sludge at the bottom of the tank will gradually increase. Once there is too much sludge, it will affect the ability of the bacteria to break down inflowing faeces and water loses room in the septic tank (Waste Disposal Hub, 2018) (Scheres, Personal Communication, May 20th 2020).

Figure 8



Source: Miguel, R. (z.d.). *What is a Septic Tank? What is a Cesspool? — Cesspool and Septic Pumping on the Big Island of Hawaii*. Geraadpleegd op 23 juni 2020, van https://abccesspoolandsepticpumping.com/septic-tank-cesspool/

If the tanks are too full, they cannot work properly, what leads to a self-enhancing counterwork. So the more sludge in the tank, the less the content will become decontaminated. Normally septic tanks work in a way that they decontaminate the water and then the water gets distributed to be used again, although if the water is not properly decontaminated due to the excessive sludge, contaminated water will get distributed. This distribution counts for people using the water as drinking water for instance, but it could also be used for watering the crops (Mitchell, 2016). If the contaminated water gets used as drinking water or similar activities, it could cause diarrhoeal diseases. Although if this contaminated water gets distributed, it will firstly end up in the ground(water) and therefore also in the surface water, which leads to the concerning pollution.

4.1.2. Maintenance of pipes and treatment plants

The Septic tanks are not the only way treating sewage. There are in fact pipes that transport the water and waste water (Odagiri, personal communication, May 18th 2020). There is a central sewage treatment plant in Yogyakarta. Although it is not a plant as it is known in Western Countries. It is named an 'Aerated Lagoon'. This is simply said a lagoon, so a man-made lake (van Son, personal communication, 2020). The purpose of the Aerated Lagoon is to oxidize the water, which cleans some of the bad components. This plant has several downsides in Yogyakarta. The first problem is because by the usage of the water treatment plant the actual water quality demands are not met (van Son, personal communication, May 22nd 2020). The Aerated Lagoon filters a part of the bad components in the water, but unfortunately not all. That means that the water quality requirements are not met. The treatment could in theory be improved and altered in order to increase the efficiency (van Son, personal communication, May 22nd 2020). But also this has thresholds, namely the absence of the proper knowledge and the fact that the sewage system in Yogyakarta is privately owned (Scheres, personal communication, May 20th 2020, van Son, personal communication, May 22nd 2020). The sewage system is privately owned because these bodies of infrastructure have been

sold by the government in the past (Scheres, personal communication, May 20th 2020). These commercial, private companies have no self interest in the social benefits coming with an improved sewage system. “Companies are not philanthropic, because they should not be philanthropic, otherwise they will go bankrupt” (Tushuizen, personal communication, May 21st 2020). Because companies are not philanthropic, they will most likely not choose a more expensive implementation above doing nothing, which is much cheaper. “It is an industry characterized by extremely high fixed costs”(Tushuizen, personal communication, May 21st 2020). And this investment will merely cost them a lot of money and a lot of time, whilst the result will not benefit them in regards to the costs (Tushuizen, personal communication, May 21st 2020; Scheres, personal communication, May 20th 2020). Another problem with the sewage system is the overall absence of proper maintenance, and sewage systems are high-maintenance. That is a part of the reason why this maintenance is rather vacant, but it does not mean that because it is high-maintenance it is neglectable. Because sewage increases the public health, which subsequently produces economic prosperity (Scheres, personal communication, May 20th 2020). This maintenance is possible on different levels. Some examples are the replacement of leaking or broken pipes, the monitoring of water composition in particular places, like upstream the city and where the river leaves the urban area (Odagiri, personal communication, May 18th 2020). This monitoring of the water composition could sketch a situation before and after the water enters the urban area of Yogyakarta and using this data about the water composition, it is possible to identify certain substances like chemicals or faeces. If there is information about presence of particular substances the polluter could be specified, so if monitoring and maintenance is left behind, knowledge about the situation follows (van Son, personal communication, May 22nd 2020).

4.1.3. “Political Scheming”

The fact that such a project costs a lot of time, introduces the next perplexity, namely the politics in Indonesia. Such projects are in dire need of government support, because an investment like that needs proper logistics. And these logistics in this case are capital and will, which could be supplied by the government. For instance a change of legislation or support for privately owned companies that could develop newer and better sewage systems (Tushuizen, personal communication, May 21st 2020). Implementations like these could induce behavioural changes in the companies. There need to be more incentives for companies to improve the water quality (Odagiri, personal communication, May 18th 2020). These incentives should support or solve the need for capital and will, in other words, the government should effectuate the companies to be willing and able to invest time and money in a project. If a company is not getting a revenue out of the investment, it will not invest. Which according to Tushuizen (personal communication, May 21st 2020) is happening on a particular, incorrect way already. The water is for a lot of less wealthy people not affordable in Indonesia.

Next to this aspect of government participation, there is also a threshold for the government to implement certain vast projects, like a renewal of the sewage system. This threshold is due to the differentiation of parties. Like a lot of other countries, Indonesia changes of government every 4 years. Although the Indonesia government does not always change to a completely different government. There are two different families in Indonesia, which are competing against each other. As a result of this rivalry big projects are hard to realise. When one government starts a project, the next government lets the project bleed out or destroy it. That is a reason why gigantic projects like a sewage system renewal are not realistic (Scheres, personal communication, May 20th 2020). “Everything with a horizon further than four years in the future is not feasible” (Scheres, personal communication, May 20th 2020).

4.2. What are the main consequences of the water pollution in Yogyakarta?

The definition of water pollution could be defined, according to Savedge (2019), as

> Water pollution occurs when a body of water becomes contaminated. The contamination could be caused by physical debris such as plastic water bottles or rubber tires, or it could be chemical such as the runoff that finds its way into waterways from factories, farms, cities, cars, sewage treatment facilities, and air pollution. Water pollution occurs any time that contaminants are discharged into aquatic ecosystems that do not have the capacity to absorb or remove them.

4.2.1. Diarrhoeal diseases

All of these formerly stated situations have applicable consequences. Firstly the consequences for the inhabitants and users of the water will be explained. In Indonesia people use several sources for drinking water. According to Komarulzaman (2017) around 60 percent of the people in Indonesia drink water from 'other water sources'. In this research the options were: bottled water, refillable bottled water, piped water, metered piped water and other water sources. Amongst the 'other water sources' are included the following: wells, springs, rain water rivers and others. As to be expected the quality of these sources are lower than (metered) piped water or bottled water (Komarulzaman, 2017). The reason why these sources are less clean than the bottled and piped water sources is because they are not treated at all. The treated water is treated to some extent while the stated sources are not (Komarulzaman, 2017). These 'other sources' could be contaminated with various harmful chemicals, bacteria, viruses or solid waste. For instance if the septic tanks are not maintained for a considerable period of time, it will leak contaminated substances in the soil and water (Scheres, personal communication, May 20th 2020). This water subsequently ends up in wells, ponds and rivers and if people drink this water they might get sick. One of the biggest consequences originating from this pollution is the presence of diarrhoeal diseases like E. Coli in the water. These diarrhoeal diseases have various effects on people. For one thing it is the biggest cause of child mortality in Indonesia (UNICEF, n.d.). And next to that the diarrhoeal diseases have an effect on the development of children. This is because the diseases lead to malnutrition with the children, what subsequently leads to growth stunting (WHO, 2017, Radar Jogja, 2018). This has consequences on itself, because these children have increased school absenteeism and are therefore less educated, which affects the economy on the long term (Komarulzaman, 2017). Not only the absence has an effect on the educational level of children, in fact the stunting itself has influence on various characteristics that people need in their life. For instance the cognitive function of children could be affected by the stunting, in this case the stunting has happened during infancy. Also if children have suffered from stunting in the second year of life, they seem to have a reduction in intelligence tests (Berkman et al., 2002).

4.2.2 Nitrate Contamination

Next to the diarrhoeal diseases caused by improper water usage, there also is the presence of nitrate in the water. nitrate infiltrates the water through bad land use, mostly concerning agricultural practices. This contamination of nitrate is the product of fertilizers and pesticides used on farms and plantations. The main reason for the growth of nitrate presence in the water is urbanisation, because the city grows, in population, but also in surface, resulting in farms needing to move to more rural areas. These are also the areas where the farmers are less monitored on land use and therefore are more reckless with pesticide and fertilizer usage. The nitrate ends up in the river and could flow downstream to cities (Pacheco, 2016). Nitrate has several health issues, among which colorectal cancer. According to research done by Fathmawati et al. (2017) there is a significant connection between the presence of nitrate and the occurrence of colorectal cancer.

Both health risks stated before are non-visible contaminations. In Indonesia there are several initiatives to clean certain rivers or ponds. Unfortunately these initiatives have very limited substantive impact on the water concerning the decrease of health risks. The reason behind this is because the waste extracted from the water is merely the visible waste, like solid waste. Although the invisible substances like E. Coli or nitrate are not filtered in the process (van der Krabben, personal communication 2020). Another threshold in these local initiatives is the shortage of communication between the villages or places where the water is 'cleaned' and the parties upstream. If there is limited or no communication between the villages sharing the river, the pollution will not be, or on a very limited scale, be treated. "The initiatives undertaken by the villages are well-meant, but not effective"(van der Krabben, personal communication, May 28th 2020).

4.2.3. Price changes

In reaction to expensive improvement of the sewage system, companies have to alter prices, to be able to survive. But the government demands everyone should be able to pay for the primary living condition, water. Because of this the price of people who are able to pay for the water will increase, in order to be able to produce the revenue streak to subsidize the water for the less wealthy. Although this way of changing the prices does not work properly in practice. Because another share of people cannot pay for the water. This group is most probably the lower-middle class. Now this group is not able to pay for the higher priced water (Tushuizen, personal communication, May 21st 2020). "Now the balance has just shifted" (Tushuizen, personal communication, May 21st 2020).

4.2.4. Land drop

A consequence as a result of the vast contamination of surface water is that it necessitates people to include new feasible manners of getting access to (drinking) water. Also the increase of groundwater extraction is connected with the rapid increase of population (Abidin, 2011). The surface water is the most contaminated, therefore water gets pumped up from deeper in the earth. So, ground water is being pumped up as an alternative for the bad water from the rivers (Van der Krabben, personal communication, May 28th 2020). If the water gets pumped out of the soil, the soil loses volume. If the volume is lost the pressing weight from the city has less counterweight. The result of this process is land subsidence, which means that the land, in this case city, sinks as it were below the sea level, which could have hazardous effects (Van der Krabben, personal communication, May 28th 2020). If the city sinks to deep, there could be a more regular occurrence of heavier floodings. These effects could have disastrous influence on housing, industries and also on the water quality of the aquifers. The effect of the subsidence of housing and industries are due to floodings, where the effect on aquifers are due to the water extraction (Abidin, 2011). An example of a city where this process is very relevant at the moment is Jakarta. According to BBC News (2018) 95% percent of North-Jakarta will be submerged and with the rising sea levels it could become most hazardous.

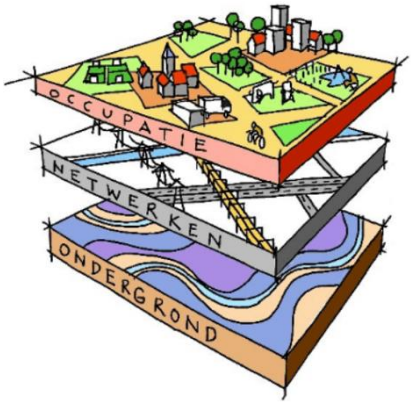
If the aquifers are drained too much, the water contained could become contaminated ((USGS, n.d.). Mostly because the 'space' created by the extraction of the clean water gets filled up by either contaminated surface water subsiding through the ground, or salt sea water that infiltrates the aquifer from the sea. Both contaminate the water, whether due to the harmful substances in the water or due to salinization (Thin et al., n.d.).There are different ways of land subsidence. For instance because of weight, so a lot of buildings that weigh down on the earth. There are a few different ways, but those are not relevant for the research. There is one thing the sorts of land subsidence have in common, namely the corresponding presence of groundwater extraction (Abidin, 2011).

4.3. Which actors are stakeholders in the problem?

The water contamination in Indonesia is mostly due to anthropogenic causes, like the bad sanitation or chemical leakage. Like the causes, the consequences have vast effects on people and their way of living as well. For instance the health risks or water shortage resulting from bad water quality. It is arguable which actors are actual stakeholders in this particular problem, given that there is a distinction between the guilty and the stricken. Are the guilty actually guilty and could the stricken act in a better way as well? In this chapter a network analysis will be done in order to expose the invisible lines between actors and the reasons why they are able or unable to act (Christis, 2014). The network analysis is an instrument applicable in bottom up approaches, which is fairly relevant in the research, because the dynamics amongst actors will be made clear (Christis, 2014).

4.3.1.The Layers Theory

Figure 9



Source: ruimtexmilieu.nl
Occupatie : Occupational Layer
Netwerken: Network Layer
Ondergrond: Green-Blue Layer

In order to clarify the ownership of natural resources the Layers Theory of Sijmons is reintroduced. As stated in the Theory chapter, the three layers distinguished in the theory are the Green-Blue Layer, the Network Layer and the Occupational Layer. Shortly recapping the meaning of the layers, the layers represent respectively the 'soil, subsoil and water systems', 'infrastructure' and 'real estate and location development'. The theory is relevant for the research, because the interdependency between the three layers in Yogyakarta is visible. The interrelations between the Network Layer ant the Green-Blue Layer for instance is mostly relevant. Because the sewage is present in several places, although it does not function like it should, or even does not function at all (Scheres, personal communication, May 20th 2020; van Son, personal communication, May 22nd 2020). This has as a result the sewage system is malfunctioning, which causes the waste water to end up in the subsoil. So a malfunction in the Network Layer, influences the Green-Blue Layer. These two layers are both subterranean, where the Occupational Layer is above the ground. The Occupational Layer has fairly clear ownership, given that it are the buildings and houses, whether privately owned or owned by the government. The Network Layer is mostly privately owned, because the government has paid companies using rights for infrastructure. For instance if a company built a road for the government, they are paid by owning (a part of) the road (Scheres, personal communication, May 20th 2020). The other layer, the Green-Blue Layer, containing the water systems, soil and subsoil have much less clear ownership. The water systems, groundwater and surface water, are common-pool resources, because they are finite, but accessible to everyone (Ostrom, 2008). This has as a result that, because they are 'owned' by everyone, they are overused. Which is explained by the Tragedy of the Commons (Hardin, 1998). This Tragedy of the Commons means if several people have access to the common, in this case the usage of water, the more people utilize the common, the worse the common will become. Mostly because it will be overused, because all people will keep using it and even start using it more, because it saves money, if used more (Hardin, 1988).

4.3.2. Inhabitants

Firstly the inhabitants, or just Indonesian/Yogyakartan people are actors in such a way that they on the one hand experience the consequences of the water pollution and on the other hand participate in polluting the water further. They suffer from the consequences in the way they and their children could get sick by the contaminated water, they have to pay more or less for the water and they might have to cope with growth stunting or worse. Although they are the group that has to cope most with the consequences, they contribute to the problem as well. For instance the article by Shukman (2018) is headlined *"Giant Plastic Berg Blocks Indonesian River".* This is an example of the hazardous presence of solid waste in rivers. This solid waste, in the form of plastic bottles and bags, mostly comes from people who have no access to the waste collecting system. As a result they toss their plastic garbage in the water. This is one of the many examples to be made about how the public contributes to the problem. "Jambeck et al. (2015) have estimated that the total volume of plastics that enters the ocean from the coastlines and waterways amounts to at 0.48-1.29 million tons each year"(Radboud University; Krabben, 2019) . Another example is the water contamination through excrement that ends up in the water. This is partly because a lot of houses are not properly connected with the sewage system, instead the waste is sent to a septic tank. Because these tanks are badly maintained they eventually treat the water very poorly or in extreme cases, not at all (Scheres, personal communication, May 20th 2020).

The sewage system in Indonesia is in the hands of private companies, so these private companies are stakeholders in the issue, because they control the infrastructure. According to the fact that these companies own the infrastructure, it could be argued these companies ought to be responsible for the maintenance as well. Although, as mentioned earlier in the research, these companies are not philanthropic (Tushuizen, personal communication, May 21st 2020. The companies are not eager to improve the system or spent coin on new jobs for maintenance, it will not increase the revenues (Scheres, personal communication, May 20th 2020). In theory these companies could be seen as the solution, but in practices they serve as the bottleneck of the issue.

4.3.3. Government

Companies need incentives to act, because there is no necessity for them to act. This is where the government should intervene. The government is the party, with authority to intervene with legislation. Using this instrument, improving or maintaining the sewage system might become more interesting for the companies. The concern is what could the government do to make companies more willing to interact and intervene in the situation. For instance triggering companies to improve proper sewage access, because there are a lot of houses and buildings that are not yet included in the sewage network according to the Yogyakarta City Government (personal communication, 2020).The result of forcing the private sector could have major economic effects on the consumers. Because companies in the private sector have to distribute their costs among their customers (Tushuizen, personal communication, May 21st 2020). This results in higher prices for water. Although changing policies in different ways, for instance subsidies, is not realistic for Indonesia, given the fact they lack the capital (Van der Krabben, personal communication, May 28th 2020). Apart from the fact that a lot of initiatives are troublesome to implement due to the capital scarcity, there are also capital-extensive opportunities, namely the TPS, or *Tempat Penampungan Sampah*. According to the community leader of a village of the upstream Code river named Gondrong (personal communication, 2020) the government is very helpful in setting up TPS's. TPS's are, simply put, temporary garbage collection places. These TPS's are used to collect the waste originating from households. Although the responsibility of taking the waste to the TPS from the household, and from the TPS to the landfill is divided. It is the household's responsibility to take their trash to the TPS. The

transport from the TPS to the landfill is the government's responsibility (Bintari, 2019). Unfortunately the TPS' do not separate the waste, and thus a lot of reusable and recyclable waste is lost. The Waste Bank, on the other hand, does separate the waste. Although the Waste Bank is not implied in the process of the TPS's. The Waste Bank should be implied in the process, in order to make sure the waste is separated. Or the TPS's should separate the waste themselves. This could be seen as a task for the government, given the fact they implemented the TPS's. Although if the waste is taken from TPS to Waste Bank in the process, there are a lot of steps until the waste arrives on its right destination, which complicates the system. This causes more room for mistakes and bottlenecks. Therefore Bintari tries to arrange for a fusion of TPS's and Waste banks, to reduce the system process length (Bintari, 2019). The first stage is more relevant in the bottlenecks of this initiative, because what makes the people bring their trash? This is where the way how people behave comes along. This is exactly where government and certain organizations, like Bintari could help. For instance Bintari tries to educate and raise awareness to incense people to deliver their trash. For example with an Municipal Waste Recycling Program. With this program the value of certain types of trash and the recyclability is declared for specific trash (Bintari, 2019). Programs like these are very important to change the behaviour of people, in order to mitigate the pollution on a municipal level. This is the most significant level where these programs could be done, because a lot of people do not act responsible, even though they are subscribed to waste transport services (Gondrong, personal communication, June 9th 2020). Gondrong also states that it is most important to alter the attitude and understanding of the community with respect to waste production and disposal. "Every person is individually responsible for the waste they produce and dispose so as not to contaminate the environment" (Gondrong, personal communication, June 9th 2020). He states that he is an advocate of creating a municipal independent waste treatment site, in cooperation with student to supervise the situation. This introduces another actor that could and maybe should be a stakeholder in the amendment of the waste situation, namely the University.

4.3.4. Universities

An availability of proper technology and the ability to actually use the technologies is a key necessity for the implementation of smart city solutions to the waste issue. Thus there needs to be an innovating actor to come up with the technology, which also has the capability of applying these technologies (Duh, 2008). Next to that, universities could play a big role in the awareness as well, for instance through starting up initiatives and new technologies (Tushuizen, personal communication, May 21st 2020). This requires the input of highly educated people to help develop, supervise and innovate relevant initiatives (Gondrong, personal communication, June 9th 2020). The Smart City is an initiative that supports policies using ICT solutions, i.e. using available data cleverly in order to execute policies and investments (Van der Krabben, personal communication, May 28th 2020). The University is an important organ to be included in an implementation of sorts, because it could be useful as innovative support. According to a Collabco (2015) paper, universities are major instances in the implementation of Smart Cities. These instances could operate firstly as a research area, tests could be done concerning the data management and also new innovative ideas could be developed (Collabco, 2015). A Smart City on the other hand is not an easy initiative, highly educated people are needed in order to construct a properly working Smart City. In this issue the university also offers a solution, because studies could be developed in the sign of sustainable cities (Collabco, 2015). Next to that universities are perfect for coordinating developments, on both economic as social levels. And given the fact that the university is in contact with other universities and has foreign students, the Smart City Concept could be diffused on a local to an even international scale.

4.3.5. Organisations

One of the major reasons for the impossibility to alter the policies and implement the right initiatives, is the lack of capital (Van der Krabben, personal communication, May 28th 2020). Therefore other parties that possess capital are necessary. For instance the World Bank is an institution possessing money and power.

> Ecological and economic sustainable Cities is a new initiative launched by the World Bank, as an integral part of the World Bank Urban and Local Government Strategy, to help cities in developing countries achieve greater ecological and economic sustainability. Urbanization in developing countries may be the single greatest change in this century. (Yadav, 2018)

The World Bank has in fact initiated various interventions in order to clean rivers and such (World Bank, 2013). Although of all the money spend by the World Bank a deceiving amount ends up at the actual project. Partly because of the corruption in Indonesia. As Scheres (personal communication, 2020) mentioned “Money is spent on water, unfortunately it is spent on private pools”. Luckily there are different interventions, more focussed on the community. There are various communities that work for better conditions. These communities are very important in the solving of the water contamination and the consequences it brings with. These are the stakeholders that could work through a bottom up approach, because there is direct contact with the common people. Therefore the small-scale initiatives are meaningful in reducing the water waste (Scheres, personal communication, May 20th 2020). These communities could help by educating or setting up initiatives for instance. An example is the STBM Program mentioned earlier (Odagiri, personal communication, May 18th 2020)

4.4. Are there possibilities or initiatives to reduce or reuse the content of the waste water in Yogyakarta?

In order to reach the goals of the SDG's, various initiatives and possibilities are available. Some are more the responsibility for the Indonesian government, others are implemented as small-scale initiatives by communities. Also, not all possibilities and initiatives are relevant for Yogyakarta, in this chapter various initiatives are discussed, which might actually be relevant.

4.4.1. Reusable Content

According to van Son (personal communication, May 22nd 2020) Septic Tanks could create a possible circular process. That is because excrement produces a certain gas if it remains in a particular room for a particular period of time. With the correct composition of bacteria and corresponding chemicals biogas could be extracted from the tank. In order to do this there has to be some sort of container with the septic tank, which collects the gas and distributes it. This biogas could be used as a substitute for fossil fuels for example. Of course the extent of biogas is not evenly to the fossil fuels, but if done on a bigger scale it might be a start (van Son, personal communication, May 22nd 2020). Not only biogas is to be extracted from waste water. For instance phosphor and sulphur could be extracted. These are minerals that could be used for manure. Sulphur for instance could be used for composting, fertilizer and specific concrete and asphalt (Järvensivu, 2015). Phosphate is also necessary for the sulphur to be turned into fertilizer. This is not the only reason the phosphate has to be extracted from the water, another reason is to prevent eutrophication. Eutrophication is the over extensive growth of algae, because of the major presence of fertile minerals, like phosphate. These algae have a bad effect on the water quality (Järvensivu, 2015).

4.4.2. Cap and Trade

The Cap and Trade Market might be a step in the right direction in order to decrease the total pollution of the water according to van der Krabben (personal communication, May 28th 2020). This specific pollution is more focused on the contamination coming from companies, or leastwise such big parties to be able to trade in pollution rights. The Cap and Trade Market works for example with emission rights. These emission rights could be traded amongst parties. For instance party A has excessive rights and party B lacks them, they could bargain a deal. For Indonesia there could be a similar enterprise initiated, but with a discharge limit in rivers (Van der Krabben, personal communication, May 28th 2020). The revenues gained through the Cap and Trade system could be used to improve or build water treatment plants. Although these companies are still not philanthropically posed (Tushuizen, personal communication, May 21st 2020). This could have consequences, for instance the position of the government. The government gains a weaker position than the investors. And those investors could exploit the weaker position of the government. This neoliberal way of thinking could result in the opposite way of what was intended if the conditions of the market mechanisms were not well agreed on (Van der Krabben, personal communication, May 28th 2020). Next to a bad consequence as discussed in prior, there are several other consequences the Cap and Trade system could have. The basis for the various bad consequences of the Cap and Trade system lie with the goal of it. The goal namely is the rise of the cost of energy. Which in continuation could harm particular groups of people (IER, 2009). For instance the less wealthy could be struck as the victims of the price-range, given that they might not be able to pay for the energy. And next to that, the fact that the emissions are tradeable could result in a market with scarcities. During a scarcity, the price will increase even further, resulting in an even higher price (IER, 2009).

4.4.3. Bottom up

The former initiative is a mostly top-down approach, because the government has to implement the policy to accomplish an emission market. But for the Indonesian government a bottom-up approach is more probable, mostly because that has been done in the past and it is a habit in Indonesia (Van der Krabben, personal communication, May 28th 2020). An example of a bottom up approach, indicated by Odagiri (personal communication, May 18th 2020) is the national STBM program, or Sanitasi Total Berbasis Masyarakat. Translated Community Based Total Sanitation. As in the name indicated the program focuses on the participation of communities. The approach tries to trigger communities to behave in another manner regarding hygiene and sanitation (STBM, n.d.). The STBM program is founded in order to reduce the bad consequences and circumstances concerning sanitation and health, so for instance the presence of diarrhoeal diseases and other environmental-based diseases (STBM, n.d.). "The five pillars of the STBM approach are open defecation (StopBABS), hand washing with soap (CTPS), safeguarding drinking water and household food (PAM-RT), household waste management (PSRT) and household waste management (PLRT)"(Radar Jogja, 2018). According to Radar Jogja, the STBM program has already proved itself to a certain extent, given that the amount of stunted child growth is decreased already. According to formerly done research, the STBM program is in fact a viable initiative to lessen diarrhoeal diseases and environmental impacts (Meliyanti, 2019). According to Scheres (personal communication, May 20th 2020), these small-scale initiatives are the most important implementations, because these initiatives are the easiest to implement and could in turn raise awareness.

4.4.4. Water monitoring

According to van Son (personal communication May 22th 2020) there are ways to monitor water and more specifically the composition of the water. This system is present in the Netherlands for one. The system could be defined as a spider like design. The body is the water treatment plant and the legs are the sewage pipes running towards the water treatment plant. In the water treatment the water is naturally checked and monitored, although if the water is merely tested at the treatment the specific location of the contamination remains unknown. If in every leg the water quality gets tested the contamination could be pinpointed more. So the goal is to monitor the water quality per area, to pinpoint the heavy polluters and treat the concerning problems (van Son, personal communication, May 22nd 2020). For instance if there are 4 areas, both with industry and domestic housing. The river is polluted, although it is not certain where the particular contamination is originating from. Thereafter the waste product of every independent area is monitored and the composition is determined. Using this information the particular area responsible for the concerning waste is uncovered. Given the fact that the area responsible is clear, the same system could be applied to narrow the parties responsible for the pollution. Concluded this system is a possibility to make parties accountable for polluting the much needed river.

4.4.5. The World Bank

The World Bank is also concerning itself with this particular water pollution problematic. An example of World Bank intervention is regarding the Citarum river, regarded the most polluted river in the world (Freischlad, 2019). According to research done by the World Bank, in 2030 the pollution will increase with circa 50%. Such numbers beg for interventions, which led to the World Bank investing and cooperating in initiatives (World Bank, 2013). The way how the World Bank influences the situation is mostly by creating some form of legislation. For instance the World Bank tries to limit the use of groundwater in order to reduce the ground subsidence. The way to do this is to increase the quality of surface water, through the increase of recycling of municipal waste (World Bank, 2013). There will be set up several sites where the waste is sorted into plastic, paper and such. This sorting

has several positive effects on society, for instance the sorting could be made into a profession. So the implementation of the three R's leads to employment opportunities, which subsequently leads to additional revenues. The jobs created differ from low-skilled jobs to semi-skilled jobs, respectively sorting the waste and in the manufacturing sector (EPA, n.d.). The separated organic waste also bears another feasibility, namely the this organic waste could be produced as biogas, and next to that, compost as well. These two possibilities coming from the waste separation, have firstly a positive impact on the river (World Bank, 2013) and on the economy (EPA, n.d.).

4.5. How could the Smart City Concept be implemented in mitigation in the water management?

Considering the formerly stated initiatives and actions, the Smart City remains a factor that could bring about the effectiveness of some of these formerly stated initiatives and actions. Next to that, according to Yadav (2016) the Smart City creates jobs as well. As much as a 10-15 % rise in employment, which has a positive effect on both the environment as the economy.

4.5.1. Smart Monitoring and leakage systems

The Smart City has in fact been implemented before, stated by Yadav (2016). The Smart City Concept has, in this case, mostly been implemented through the ability of efficient data management. There are various water monitoring stations that monitor the water in order to know the composition of the water. With this information the polluter could be pinpointed and the appropriate actions could be undertaken to improve the water quality (Yadav, 2016). This is a very relevant asset in Yogyakarta, as the Yogyakarta City Government (personal communication, 2020) indicates one of the major problems processing waste is that not all of the sources register how much waste they produce. As graphically explained in the appendix 1 (Yadav, 2016), the Smart City System concerning waste water is visualized. In the first part of the appendix (Yadav, 2016) (Page 1) the waste water flows are explained, in the second graph a similar waste flow graph is visualized, although with the concerning Smart City Concept initiatives implemented. It is to be seen that before the surface and ground water is being used, it is thoroughly analysed, in order to improve future planning. Before the water is to be actually used, the characteristics of the water are known. The first acquaintance with the water is not the only phase where the water is monitored. There should be monitoring between as much phases the water flows through as possible, in order to locate and treat other contaminating factors (van Son, personal communication, May 22nd 2020; Yadav, 2016). Another asset of this monitoring system is the Smart Leakage system. Which can locate the leaks, so they can more easily be repaired. In the case of Yogyakarta, this particular Smart Waste Water system requires some altering. The threshold for implementing this particular initiative in Yogyakarta is the cost. According to Yadav (2016) the costs for the implementation are very high, because of the vast projects necessary to realise the results. For Indian cities, approximately 14 billion US dollars is granted for the development of the improvement and implementation of 100 Smart Cities. So on average it could be stated the costs of one Smart City are circa 14 million US dollars. But, in theory this initiative is an interesting opportunity to mitigate the water contamination, and mostly the prevention of diseases and the presence of harmful substances in the water. Subsequently this has an effect on the pumping of ground water, if the piped water is cleaner. This counteracts the land subsidence.

4.5.2. Circular economy

An important aspect of the Smart City Concept is the circular economy, which is applicable in this situation. According to Son (personal communication, 2020), as stated in the previous chapter, various components of the waste water are reusable or recyclable. This has the potential to turn into a circular market concerning these particular components. For instance the phosphor extracted from the water could be turned into new fertilizer in order to improve crop growth. But next to the non-visible contamination, the visible is to be recycled or reused as well. For instance the immense presence of plastic bottles and bags (Shukman, 2018). Plastic is reusable and if this waste is collected by the communities as stated by Krabben (personal communication, 2020), this waste is to be recycled. The plastic recycling industry is a relevant initiative for Indonesia in order to clean the rivers, for instance because it is fairly cost-effective and efficient due to ongoing recycling technologies (Leblanc, 2019). This might be combined with smart waste collection systems, like the one researched by Sakti (2018). Sakti argues there is a possibility to implement smart waste

collecting routes. Which implies firstly strategic placement of waste recycling or waste-based power plants and secondly smart routes. If the routes are as efficient as possible, due to central plants and the shortest-as-possible routes, the result will be a system that minimizes the vehicle costs, facility costs and travel costs (Sakti, 2018). Thus, an initiative similar or the same checks multiple requirements of the Smart City Concept. For instance the reduction of environmental impacts, firstly due to the improved collection of waste and secondly by the smart routes, which reduce emission of transport. But in order to realise an improved collection system, people have to dispose on a proper manner (Tushuizen, personal communication, May 21st 2020). The fact that the behaviour of people is indispensable, introduces another aspect of the Smart City Concept.

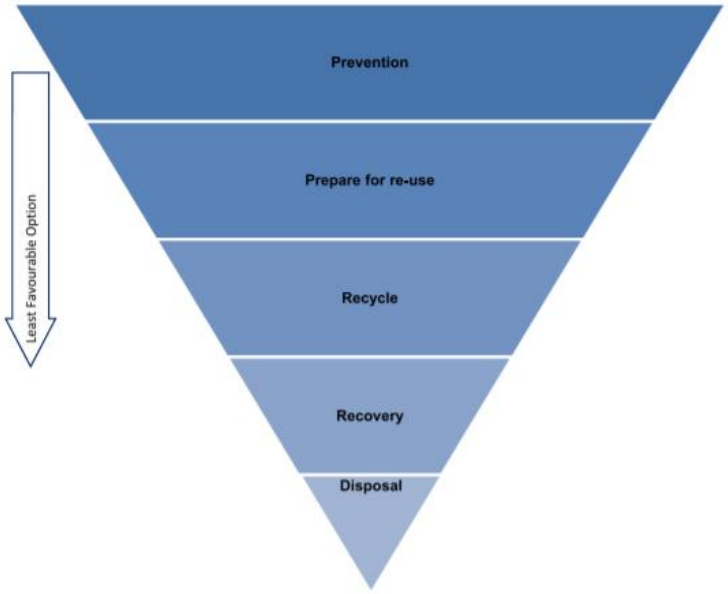
4.5.3. Knowledge, education and awareness

> Smart cities of the future will need sustainable urban development policies where all residents, including the poor, can live well and the attraction of the towns and cities is preserved. Smart cities are cities that have a high quality of life; those that pursue sustainable economic development through investments in human and social capital, and traditional and modern communications infrastructure (transport and information communication technology); and manage natural resources through participatory policies. Smart cities should also be sustainable, converging economic, social, and environmental goals (Thuzar, 2012) (Albino et al., 2015).

The quotation of Thuzar (2012) above states sustainable economic development is pursued through investments in human and social capital. Investments in human and social capital could be defined as resources embodied through the structures of relations and group activity (Kalkan et al., 2015). Considering Smart Cities are meant to provide a high capacity for learning and innovation, the highly educated people play a big part in the development of the Smart City (Albino et al., 2015). The students could innovate and next to that set up, lead and support initiatives to improve the water quality (Tushuizen, personal communication, May 21st 2020). In regard to the investment in human capital, according to Bourdieu, education provides a contribution worth mentioning. Education can change social and cultural capital. The cultural capital is a way to induce change in people, because the “the educational system presupposes the possession of cultural capital”(Sullivan, 2001). Minorities have a disadvantage in this case, because this group of people might not have taken in the same cultural capital as the more fortunate people (Sullivan, 2001). This is where change is possible through the improvement of awareness using education to actualize this awareness, which subsequently could mean the awareness becomes part of the cultural capital. There are other ways of educating and creating awareness across a populations, for instance through internet (Logicladder, 2017). Logicladder (2017) for instance, has created a citizen mobile app, in which citizens could check the water and air quality, based on their geolocation. If people are common with the changes, positive or negative, they have more knowledge about the issue. As stated, education holds a considerable role within the Smart City Concept, because one of the major necessities for a Smart City is knowledge and awareness. Apps like these could be used with a nudging effect as well (Sunstein, 2018). For instance to provide people with opportunities to help with programs like STBM (Odagiri, personal communication, May 18th 2020). Or another possibility is to provide people with information about proper disposal behaviour.

This is where the Waste Hierarchy discussed in the Theory chapter is applicable, considering the improvement of behaviour through awareness.

Figure 10



If people are educated to use their waste properly, they might be able to even follow higher steps in the Ladder of Waste (Papargyropoulou, 2015). Maybe, if people are familiar with the best way to use their waste, they will less likely dispose their waste and at least try to recycle it. At the moment, a big part of the waste is still disposed, very likely on a bad manner. For instance thrown in the river or burned, from what the remains will end up in a river after rain fall (Scheres, personal communication, May 20th 2020).

4.5.4. Application of Smart systems

Yadav (2016) argues the Smart City has a positive effect on the job market, given the employment rises with approximately 10 to 15 %. In this particular case, jobs are very indispensable. A part of the problem, namely the maintenance and improvement of the septic tanks and sewage systems are issues that could be improved using manpower. There are various levels on which the particular issues could be decreased. Namely the physical aspect and the technological/educational aspect (Tushuizen, personal communication, May 21st 2020). For instance for the maintenance of the sewage system. Through smart leakage systems, maintained by highly-educated people, the problems can be located. These smart leakage systems exist in different forms. For instance leaks could be located using GIS (Geographic Information System), through detailed maps, combined with monitoring of the sewers (Smartcity, 2018). When the problem is located, communication between the data centre and the people educated to repair or improve the pipes will provide the reparation. Jobs concerning maintenance are not common in Indonesia (Scheres, personal communication, May 20th 2020), which is part of the problem. So the government and private companies should make resolutions in order to achieve the presence of maintenance jobs in the sewage management. Public-Private collaborations are needed to have both an executive and a wealthy party. Also the university is important to be included in the collaboration, so it could act as an innovative actor in the development of the Smart City (van der Krabben, personal communication, May 28th 2020). To start these initiatives, it is important to not implement it on a big scale in the first place. It is very helpful to implement the Smart City Concept through a bottom-up approach. “If you want to realise the Smart City Concept, you have to create awareness that there is a win-win situation for everything.

Then, the ‘small’ parties, but also the ‘big’ parties will invest” (Scheres, personal communication, May 20th 2020).

So, if the small-scale initiatives develop awareness and interest, the ‘big’ parties might have to invest in the future, because the commercial private sector reacts to the demand. If the demand is obviously clean water, it might trigger the companies to take action. Just as with the demand for Coca-Cola, it is available in all of Indonesia, because there is demand for Coca-Cola. If there is enough clear demand for clear water, it might trigger the big private companies (Scheres, personal communication, May 20th 2020).

5. Conclusion

The research aims to answer the following research question:

How could water pollution in agglomeration Yogyakarta be mitigated using the Smart City Concept?

This question is answered by answering the sub questions, which respectively focus on the causes, consequences, stakeholders, initiatives in water management and lastly the implementation of the Smart City Concept.

5.1 Discussion

There are various causes affecting urban water contamination in Indonesia, all with concerning actors and stakeholders. But in the end everyone has to deal with the consequences. There are initiatives undertaken to decrease the pollution, for instance the septic tanks. These tanks are mainly to decontaminate the water and make sure the water comes out as clean as possible. In theory these septic tanks work, although in practice they fail to meet all the expectations. This is mainly the effect of lack of maintenance. Because there is too little maintenance, the waste water that should be 'cleaned' by the septic tank, is practically as contaminated as in the first instance. The fact that the maintenance is bad is due to various factors, for instance the possession of these tanks and sewage systems. These are all owned privately. Companies own it, and because maintaining it on a big scale or improving it, costs too much money. If a company intends to be philanthropic, it will most likely go bankrupt. Of course the government could intervene, for instance by improving the sewage system or other projects. The government on the other hand firstly does not possess enough capital to intervene on a project as massive as the sewage system improvement. And next to that, the corrupt and ever changing government is not letting big projects start off.

The water contamination has various consequences, ranging from diseases to economic changes to the actual subsidence of the earth. In Indonesia, most people cannot drink water directly from the tap, which is why they have to embrace other sources of water. For instance bottled water or from rivers and ponds. The second sources are much more contaminated than bottled or piped water. Through this water diseases could be transferred, mostly diarrhoeal diseases like E. Coli. These diseases have various effects on people coming in contact with them. For example children could get really sick and even die. Also the sickness could influence their growth, with the result of underdeveloped people. This results thereafter into an increase in school absenteeism and lower grades in intelligence tests. Another issue of the water quality is the presence of nitrate in the water. Nitrate infiltrates the earth, after using fertilizer and pesticides irresponsibly. Nitrate could cause health risks as well, not in the form of diarrhoeal diseases, but there is a significant correlation between the presence of nitrate in the water and the occurrence of Colorectal cancer.

Because of the hazardous consequences of drinking and using the contaminated water, people are using alternative sources for water. Namely ground water. The water gets extracted from the ground, or out of aquifers. This has two major consequences, firstly land subsidence. This is the process where due to over extraction of water out of the soil, the ground starts to lose 'volume'. Because of this the ground will sink. The other consequence of draining the aquifers is the fact that contaminated and salty sea water get room to infiltrate the 'clean' ground or aquifer water.

These causes and consequences do have stakeholders who suffer from the consequences or influence the causes. Analysing the situation led to a discerning of 3 key stakeholders. Firstly this concerns the local city inhabitants. These inhabitants are both polluter and pollutant, because they on the one hand contribute to the problem, but on the other hand experience the concerning consequences. The reason for their improper disposal behaviour could be because of lack of

alternatives For instance some rivers in Indonesia are packed with plastic waste, which mostly comes from domestic housing (Shukman, 2018). Secondly the private sector is an important stakeholder, given that these private companies possess a lot of the infrastructure in Indonesia. Among others the sewage system. So it could be argued that these private companies are responsible for maintaining the sewage systems and septic tanks. This is not as easy as it seems, because these companies have to make profit, otherwise they might seize to exist. Thirdly the government could induce policy in order to incense the companies into improving the sewage system. Unfortunately this has negative consequences as this will have negative effects on the users of the sewage on the long term, because the price will go up if the companies are forced to make more costs. The government also initiates programs themselves. For instance the government sets up TPS's to gather the waste and afterwards aims to separate it. This system is not perfect yet, because there are too many transport phases. This process has to be shortened in order to improve the effectiveness and the government is trying to reduce the phases from household to landfill. The next initiative the government attempts is to improve the awareness and behaviour concerning disposal behaviour on solid waste, but also defecation. This is where the universities could interact, by creating initiatives and education on a higher level and in order to make the system more durable and sustainable. These universities are indispensable of creating a Smart City in order to make the waste and sewage system more efficient and sustainable. Of course other organizations are helping to reduce the water waste as well. Partly because for the government and companies capital is an issue, mostly because intervening in the sewage system is very expensive. The World Bank has invested and started various initiatives in order to clean Indonesian rivers, not always with good results. That is due to the presence of a lot of corruption. Next to the World Bank, there are several small-scale initiatives, that are working from a bottom-up approach. So approaches that incense people to behave better and help up clean the rivers and dispose less and better.

These consequences are not taken for granted and therefore initiatives on different scales are undertaken. There are initiatives that focus on technological improvements in order to salvage specific parts of the water composition, initiatives with the goal of changing the behaviour of people or companies and initiatives with an economic perspective. Firstly the septic tank could have more potential than merely a water decontaminator. The septic tank could be used to turn the excrement into biogas with specific adjustments to the system. If done properly, the excrement of people could be reused as biofuel. Next to biogas, phosphor and sulphur could be extracted from the water as well. These minerals could be reused for among others manure or specific kinds of concrete.

A more economical solution is creating a market around pollution. A market similar to the emission market, the cap and trade market. The Cap and Trade Market could be an initiative in order to reduce the pollution and waste disposal for particularly companies. The different companies can trade in the disposal rights in order to meet the needs of the disposal maximum. The bad side of this idea is the fact that the government weakens their own position, energy pricing increases, leading to shortage for less wealthy people. A good part however is the possibility to use the revenues gained through the Cap and Trade Market for the improvement and building of water treatment plants. Next to this fairly economic top-down initiative, there are more bottom-up approaches as well. An example of an bottom-up approach is the STBM program. This is a program to incense communities and people to help building their own sanitation and waste disposal in their community. The World Bank assists in these bottom-up approaches, for instance by legislating people into using less ground water and therefore increasing the water quality of the surface water. This helps partly due to the creation of jobs, the improvement of water quality and lastly by decreasing the chance of land subsidence. According to Son (personal communication, 2020) One of the key things that make the

pollution possible is the lack of monitoring. According to him the structure and system of monitoring should be altered in order to be able produce useful and realistic data.

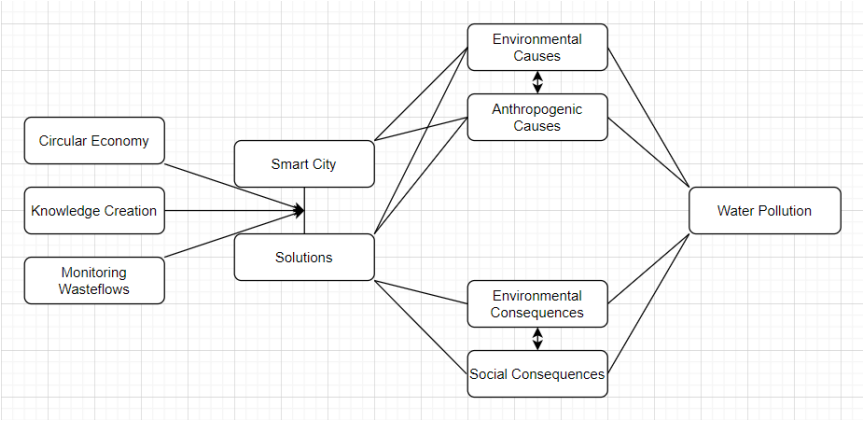
The Smart City Concept is a possibility to improve the situation around waste water management and the presence of high water pollution. Various ways of implementing the Smart City Concept in Indonesia, and specifically Yogyakarta are possible. Firstly monitoring, or rather data management. The data management means, the composition and quality of (waste) water is known. If the water is monitored on several levels, the causing situation can be located, which results in a more efficient approach to solve the cause. A major problem of this system is the price, unfortunately an implementation of sorts could cost up to 14 million US Dollars. Secondly Circular Economy is an important aspect of the Smart City Concept. Waste water contains multiple materials that could be used again, for instance phosphor, sulphur or simply plastics. This has as a result that firstly the water quality improves, whilst creating a new market, which has a positive effect on the economy. Ways to decrease the disposal of plastic waste in the river is for instance using smart routes and smart placement of waste-based power plants. If this system works, it means less waste ends up in nature and the rivers, and thereby energy could be produced using the solid waste. Thirdly education, one of the major pillars of the Smart City Concept. If the human and social capital can be changed, the activities can be altered as well, according to Bourdieu. So if people are educated right, their awareness will increase. Examples for this awareness is through a citizen mobile app or changes in the educational system. Another asset of the improvement of education is people are better educated. With the new system of leakage systems and smart water management, highly-educated people are indispensable. Jobs concerning the reparation and maintenance of sewage and septic tanks are created because of the new system. But also jobs in leading operations and innovating new technologies in order to improve the system even further.

The Smart City is a potentially relevant initiative to implement in order to mitigate the causes of pollution in the urban rivers in Yogyakarta. Partly because a lot of the initiatives discussed in the result section are applicable to Yogyakarta. For instance the creation of a circular market of extracted plastic. The plastic extracted from the river, could be reused. The plastic recycling industry is fairly cost-effective and efficient. Next to that, it creates jobs in transport and plastic extraction, which could be as asset in the development of a recycling industry. The job creation is very important in tackling the water pollution, because the sewage system lacks maintenance and development in Indonesia. Jobs could be created in the plastic circular market and in maintenance of sewage systems. Secondly, the Smart City Concept focuses on education, awareness and knowledge creation. Through ICT opportunities knowledge is diffused among people. Apps and similar initiatives nudge people through reminders and warnings, which results in people having a second thought about their action. Of course, there are people with lack of alternatives. Fortunately bottom-up approaches like STBM offer a chance of creation of alternatives. Initiatives like these could be made more well-known with ICT solutions like the app named above. This gives people the chance to create alternatives. The World Bank offers help in similar projects, that results in the presence of capital, which is one of the biggest thresholds of successful acting. Also, the presence of the university provides the city with an innovating actor that could start up and lead projects in order to clean the river water. The presence of a university is an important asset for the implementation of a Smart City as well, given that a Smart City requires highly-educated people to realise and operate it.

5.2 Reflection conceptual model

To be able to answer the research question of the research, a second interpretation of the conceptual model is useful, because now the new information gained from the results can be applied. According to the results, the three pillars of the Smart City in the conceptual model have in fact been fairly important according to the interviews and literature research.

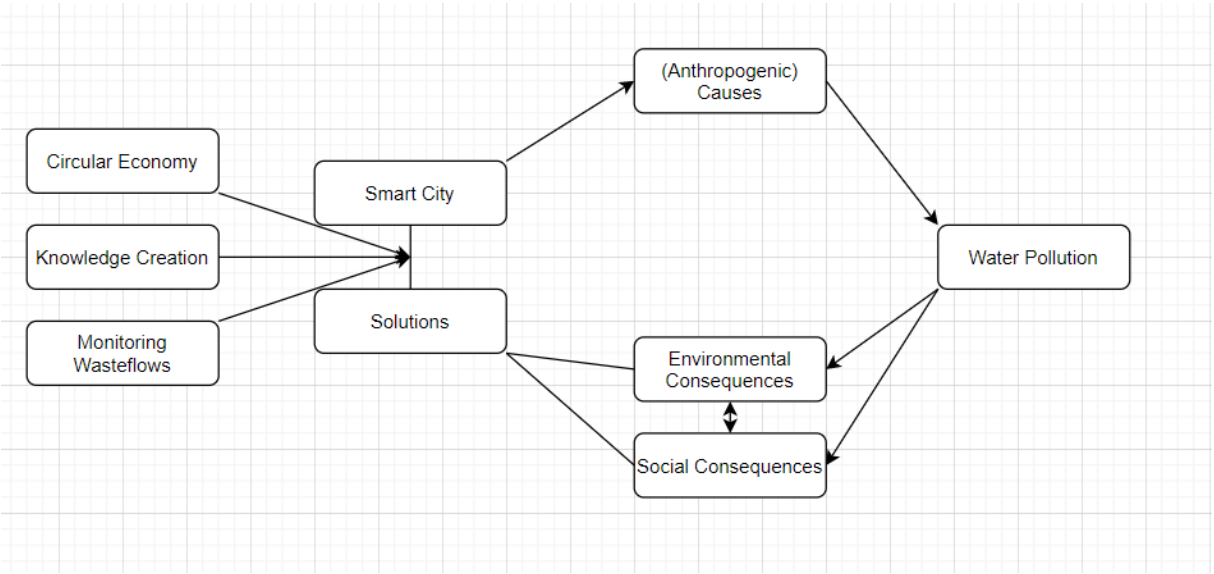
Figure 11



Circular Economy, Knowledge Creation and Monitoring Waste flows are discussed in the research and applied to the situation in Yogyakarta. Respectively through initiatives like phosphor, sulphur and plastic reusage and recycling, education, awareness and knowledge creation through mobile apps and community initiatives and lastly through Smart Monitoring and Leakage systems. These pillars of the Smart City are supposed to intervene in solutions, to achieve a Smart City, to in turn, mitigate the Causes. In the original conceptual model, both anthropogenic and environmental causes are discussed. According to the results the causes are actually particularly anthropogenic causes, given they are caused mainly due to human acting. Which is the reason why the revised conceptual model does not need to mention environmental causes. Next, the consequences, which are divided into both anthropogenic and environmental as well. The consequences are according to the reason both social and environmental. Because the health risks, such as diarrhoeal diseases and Colorectal Cancer, or price changes are mainly social, where land subsidence and contamination are both social as environmental.

Revised conceptual model

Figure 12



The revised conceptual model shows the environmental causes are left out, but next to that arrows are placed between factors. In the first place most of the arrows in the model were just lines, so there was no clear causal effect. According to the research there is in fact an effect between several of the factors. For instance the causes discussed lead in fact to water pollution and this water pollution results in the discussed consequences as well. The most important causal effect in the conceptual model is the arrow between 'Smart City' and '(Anthropogenic) Causes'. This arrow indicates the Smart City can actually affect the causes leading to urban water pollution. According to the research conducted and the comments of experts and literature, the Smart City would in theory be a potentially relevant opportunity in order to reduce water pollution in Yogyakarta. A big threshold, on the other hand is the cost, given the implementation is very expensive. This is why the Smart City should be implemented through a bottom-up approach. This way, people will develop awareness and demands and that will affect the companies owning the water systems. In the implementation of these small-scale initiatives the University, government and other organisations like the World Bank could support the development of such initiatives.

5.3 Recommendations

For future research, it would be very interesting to include more input of the inhabitants, when they are approachable again. The shortage of inhabitant opinion and perspective might be the shortcoming of this research. It is important for future research to know firstly the perspective of people, because maybe they do not prioritize proper disposal above working or similar. Also opinions on initiatives are interesting to include in the research, because people might not like the fuss around their living area. Plus, maybe these people have more realistically implementable solutions, so it would fit more with the city. In this research there has not been very much attention to industrial contamination, which might be important and interesting to include. If the Smart City could influence the disposal behaviour of industries as well.

5.4 Reflection

Reflecting at the research conducted, there are several things I have learned. Some learning points I encountered doing the right things, but there are also things I learned the hard way. First of all, I have learned not to underestimate a research of this extent. The last period of the research I was

living like real recluse. Working long days on the thesis. I could have, and should have spread the actual completing of my thesis over a longer period of time, so I could have read it over some extra times. However, I think this busy period in the end of a thesis is part of the experience. Next to that, the euphoria of handing it in is extra satisfying. Another thing I learned is that it is very hard to conduct a research concerning a research area, which is inaccessible. So maybe I should time it the next time, so there is no global pandemic. Nevertheless, I must admit I have enjoyed writing about the subject, which I find very interesting and the way of conducting research is challenging yet instructive.

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